1903.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 9.

THE

Geological Features and Mineral Resources of Northampton,

BY

A. GIBB MAITLAND,
Government Geologist,

WITH

APPENDICES

BY

H. P. WOODWARD, JOHN PROVIS, and E. S. SIMPSON.

Issued under the authority of the Hon. H. Gregory, M.L.A., Minister for Mines.

WITH A MAP AND SECTIONS.

PERTH:
BY AUTHORITY: WM. ALFRED WATSON, GOVERNMENT PRINTER.

1903.

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 Summary Report; The Staff; Field Work; Principal Results of the Year's Field Operations; Kalgoorlie Goldfield; Phillips River Goldfield; Gold Finds on the Preston and Fergusson Rivers; The Present Condition and Future Prospects of the Greenbushes Tinfield; Boring for Coal near Albany; North Lead, Kanowna; Bulong Deep Leads; Coolgardie Deep Leads; Alluvial Deposits, Donnybrook Goldfield; Subsidy to the Norseman Gold Mines, Ltd.; Gascoyne District; Extension of Artesian Water-carrying Strata from South Australia; Laboratory Work; Office Accommodation.

5. Progress Report for the Year 1901, containing—

 Administrative Report; The Staff; Field Work; Laboratory Work; Mineral Collection; School of Mines; Principal Results of the Year's Field Operations; Kimberley; Uaroo Find, Ashburton River; Gascoyne; The Island, Lake Austin; Mount Ida; Yardarino Bore; The Dundas Goldfield; The Phillips River Goldfield; Norseman Gold Mines, Limited; Alluvial Deposits, Siberia.

6. Progress Report for the Year 1902, containing—

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III. The Geology of the Coolgardie Goldfield: by Torrington Blatchford, B.A., F.G.S., Assistant Geologist.

IV. The Mineral Wealth of Western Australia: by A. Gibb Maitland, Government Geologist.

V. The Phillips River Mining District: by Torrington Blatchford, B.A., F.G.S., Assistant Geologist.

VI. Notes from the Departmental Laboratory: by E. S. Simpson, B.E., F.C.S., Mineralogist and Assayer.

VII. Notes on the Auriferous Reefs of Cue and Day Dawn: by W. D. Campbell, Assistant Geologist. With a map.

VIII. Lennonville, Mount Magnet, and Boogardie, Murchison Goldfield. C. G. Gibson, B.E., Assistant Geologist. With a map.

IX. The Geological Features and Mineral Resources of Northampton: by A. Gibb Maitland, with Appendices by H. P. Woodward, John Provis, and E. S. Simpson. With a map.

X. Palæontological Contributions to the Geology of Western Australia. I. Descriptions of Carboniferous Fossils: by R. Etheridge, jun., Curator of the Australian Museum, Sydney.

In preparation:

Notes on the Country between Edjudina and Yundamindera, North Coolgardie Goldfield: by A. Gibb Maitland, Government Geologist. With a map.

Geological Observations in the lesser known portions of the Kimberley Division: by A. Gibb Maitland and C. G. Gibson. With a map.

The Kalgoorlie Goldfield: by A. Gibb Maitland, W. D. Campbell, and E. S. Simpson.

To be had on application at the Geological Survey Office, Perth, Western Australia.

1898.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 1.

BIBLIOGRAPHY

OF THE

GEOLOGY OF WESTERN AUSTRALIA,

BY

A. GIBB MAITLAND,
Government Geologist
(Formerly of the Geological Survey of Queensland).

Issued under the Authority of the Hon. E. H. Wittenoom, M.L.C., Minister for Mines.

PERTH:
BY AUTHORITY: RICHARD PETHER, GOVERNMENT PRINTER.

1898.

PREFACE.

THE following Bibliography contains a list of Works, Papers, Reports, and Maps bearing upon the Geology, Mineralogy, Mining, and Paleontology of Western Australia. Its compilation was originally commenced during the time I was an officer on the Staff of the Geological Survey of Queensland. The labour was undertaken with the object of enlarging my knowledge of the literature of Australian Geology, and with the hope of being able to keep up to date the Catalogue of Works, Papers, Reports, and Maps prepared by Messrs. Etheridge and Jack in the year 1880, and to which I am indebted for much information.

My appointment as Government Geologist of Western Australia rendered the completion of the list, so far as was possible without access to well stocked scientific libraries, peculiarly appropriate; and, on being submitted to the Honourable the Minister for Mines, the Bibliography was ordered to be printed for public information.

To my predecessor, Mr. H. P. Woodward, I am indebted for having unreservedly placed at my disposal a short manuscript list of works bearing upon the Geology of the Colony, which he had prepared from the records of the British Museum.

A. GIBB MAITLAND.

Geological Survey Office,

Perth, 12th March, 1898.

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1898.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 2.

1.—The State of Mining in the Kimberley District;

2.—The Probability of obtaining Artesian Water between the Pilbarra Goldfields and the Great Desert;

BY

R. NEIL SMITH, M.A., F.G.S.,

MINING ENGINEER.

Issued under the Authority of the Hon. H. B. Lefroy, M.L.A., Minister for Mines.

Perth:

BY AUTHORITY: A. CURTIS, ACTING GOVERNMENT PRINTER.

1898.

PREFACE.

IN December, 1897, owing to there being no officer of the Geological Staff available, Mr. R. Neil Smith, M.A., F.G.S., Mining Engineer, of Kalgoorlie, was specially employed to report upon the state of Mining in Kimberley district.

On his way back from the North Mr. Smith was deputed to visit the neighbourhood of Warrawagine Station, to inquire into the possibility of obtaining a supply of artesian water between the Pilbarra Goldfields and the Great Desert. The reports, on being submitted to the Hon. The Minister for Mines, were ordered to be printed for public information.

A. GIBB MAITLAND,
Government Geologist.

Geological Survey Office,
Perth, 12th July, 1898.

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1.—The State of Mining in the Kimberley District.

The Kimberley District embraces all that portion of Western Australia forming the watersheds of the Fitzroy and Ord Rivers, and the country between them. Two roads have been opened and telegraph lines laid down, one South from Wyndham to Hall's Creek, and one East from Derby to Hall's Creek. These roads are of a distance of 250 and 350 miles respectively. Proceeding from Wyndham the road traverses river valleys between prominent flat-topped carboniferous (Woodward) ranges for a distance of about 100 miles. These ranges are succeeded by highly contorted Devonian (Hardman) country, which continues in two approximately parallel belts in a South-Westerly direction to the fringe of the Great Desert South of Mount Dockrell.

Between these two strips of Devonian country the road continues along granite and gneissic country until a distance of about 200 miles from the coast is reached.

At this point highly inclined shales and sandstones, in places considerably metamorphosed, make their appearance and continue without interruption except by occasional diorite or basaltic dykes as far as Mount Dockrell. This is the auriferous belt of the Kimberley Goldfield. It consists of stratified rocks evidently older than the Devonian, but its exact geological age is indeterminate, no fossils having been found in any part of it.

In many respects it considerably resembles the Lower Silurian deposits of the western part of Victoria, and the Upper Silurian of several parts of New South Wales. The sandstone is more micaceous, and the shales on the whole exhibit less of a true slatey cleavage than is seen on the Victorian fields. This has been already pointed out, I believe, by Mr. Hardman in his report published in 1885. The various portions of this auriferous belt, on

which work has been done, succeed one another in a South-South-Westerly direction, and are as follows, beginning from the farthest North:—

The Panton River and Dry Creek.
Hall's Creek.
Brockman's.
Ruby Creek.
The Mary River.
Mount Dockrell.

The extreme distance from the Panton River to Mount Dockrell is about 120 miles, the Panton River itself being about 210 miles from Wyndham. I shall give a description of these various localities, and conclude my report with a general description of the resources of the field, based on the observations made at the different centres.

HALL'S CREEK.

The general appearance of the country here is that of a series of prominent ridges running in a North to North-Easterly direction. Some of these ridges are "razor-backed," having a conspicuous "backbone" standing vertically some 10ft. to 20ft. above the sloping sides of the ranges. On inspection this "backbone" is found to consist of a dyke of felsite, conforming in strike and dip with the surrounding stratified country rock.

The country, as a whole, consists of micaceous sandstones and shales highly inclined, with a North-North-Easterly strike and generally underlying to the East. These shales and sandstones form conspicuous outcrops on the side of the ranges, and, owing to the unequal weathering of the different layers of minerals, present a highly laminated appearance. The sandstones are generally highly micaceous, the mica being arranged in layers parallel to the strike of the rock. They vary in colour from yellow to dark green. The shales are of a green or blue colour, and also exhibit mica in the laminations. Some of the shales exhibit a slatey cleavage parallel to the direction of the strike, and probably due to an East and West pressure. Others pass gradually into mica schists.

In some sections the shale or slate is seen in narrow bands 1in. to 3in. wide, and 2ft. to 5ft. apart, the intervening rocks being micaceous sandstones. In other sections the shales are seen to attain a thickness of many feet. The strike of the mountain ranges, the strike of the sandstones and shales, the direction of the schistose layers of mica, and the trend of the great felsite dykes, all

point to the fact that the main fissuring of the country will be in a like direction, that is to say North-North-Easterly. Gneiss, exposed in the bed of the Bow River some 100 miles North, exhibits the same direction in the arrangement of its minerals.

Diorite dykes occur in places generally conforming in direction with the strike of the country, but in a few instances running across from East to West.

Basalt dykes occur on the road from Wyndham, and a great sheet of basalt, the "Great Antrim Plateau," lies some 30 miles to the East, and on the Eastern side of the Ord River.

Mining, other than by a few alluvial fossickers, has completely stopped at Hall's Creek.

The "Jubilee" (*vide* Plate 1, Fig. 1) shaft has been sunk, with the aid of the Government bonus for deep sinking, to a depth of 30ft. below the 100ft. level, but a portion of the workings is now inaccessible. Where it is possible to descend it is seen that the reef varies from 18in. to 2in. in width, and has an East and West strike across the country rock, which here consists of indurated dark blue schists with a North-North-Easterly strike. The reef consists of quartz stained with oxide of iron, and containing a considerable quantity of galena. It has been stoped out from a drive 30ft. long from the 40ft. to the 20ft. level. This portion of the stone yielded, according to the published returns, 490ozs. of gold from 23 tons of stone. The Government bonus for deep sinking was utilised to sink the main shaft from 100ft. to 130ft., but as no further work has been done, and the mine is now abandoned, the presumption is that no stone below this 40ft. level was payable. Out of the above-mentioned crushing returns 362ozs. were obtained from $5\frac{1}{4}$ tons of stone. This reef is undoubtedly a segregation vein, one which cannot be depended upon to continue for any considerable distance either in depth or in the direction of the strike. An assay of stone taken from the 40ft. level gave a result of—tellurium *nil*; gold, 4dwts. 7grs.; silver, 1oz. 15dwts. per ton.

The "Lady Broome" (*vide* Plate 1, Fig. 1) is another abandoned mine at Hall's Creek. The reef, as far as could be seen, is 3in. to 9in. wide, and, like the "Jubilee" reef, runs across the country with an East and West strike. It has been exploited by two shafts 90ft. apart and 70ft. deep. No mineral could be seen in the quartz lying on the surface. An assay of this stone gave a result of—gold, trace; silver, 2ozs. 5dwts. 4grs. per ton; tellurium, *nil*. The country rock consists of a bluish shale. The only crushing return was previous to 1897, and amounted to 30ozs. from 400 tons of stone.

The "Lady Broome North" has also been abandoned for years. The stone lying on the surface contains a small amount of galena and oxide of iron. A little calcite is also present. These three mines, the "Jubilee," the "Lady Broome," and the "Lady Broome North" are all situated on the side of a hill, at the foot of which a gully runs from which a considerable amount of alluvial gold has been taken.

To the North of Hall's Creek, and some $1\frac{1}{2}$ miles distant from these mines, lie the "Jackson's Reef" and the "Jackson's Reef South."

"Jackson's Reef" (*vide* Plate 1, Fig. 1), originally held by a company, has been abandoned for many years, and the shaft is now inaccessible. It could be seen, however, that the reef consisted of a small quartz vein and a few stringers of quartz laminated with the schists, which are here very hard. The reef is a segregation vein, and, therefore, of but short duration. The crushing returns from this vein were 56ozs. 18dwts. from 78 tons of stone.

"Jackson's South" contains a vein somewhat resembling that in "Jackson's Reef," but smaller. It will be seen from the sketch that all these mines are situated on a strip of country some half-mile wide and close to one of the prominent felsite-backed hills.

With regard to Hall's Creek generally, it may be said that there is no indication of any true fissure reef. The reefs which have been worked consist of segregation veins running either with or across the strike of the country rock. These veins, where found to be payably auriferous, have been only 9in. to 12in. thick. The quartz, as a whole, contains a large proportion of galena, and, in places, smaller quantities of iron pyrites, copper pyrites, malachite, and hematite.

The great felsite dykes forming the crown of the more conspicuous hills contain innumerable quartz veins running in every direction, but no gold has been found in these.

There is no battery at Hall's Creek. Fuel is plentiful on the field, and there is a fair amount of timber suitable for heavy work. Lighter timber for underground work is plentiful. Underground water is plentiful, being struck at a depth of from 50ft. to 200ft.

BROCKMAN'S.

The workings at "Brockman's" lie some eight miles from Hall's Creek in a South-Westerly direction.

The general contour of the country is somewhat similar to that at Hall's Creek, the rocks of the district also bearing a close

resemblance to those at the former place, consisting of alternate beds of metamorphosed sandstones and shales. The sandstones are micaceous like those of Hall's Creek, but both the sandstones and shales are in most places of a lighter colour, indicating that they contain a much smaller proportion of decomposed hornblende. These strata are highly inverted, and strike in a North-North-Easterly direction.

The alluvial gold was much richer and more widely distributed than on any other portion of the Kimberley Goldfield. Most of the gold-bearing quartz reefs have been discovered by tracing up their connection with the neighbouring alluvial. The only mine being worked at present is the "Mount Bradley Tunnelling Claim." (*Vide* Plate 1, Fig. 2.) Many others have been worked, but abandoned years ago. There are three men employed on the "Mount Bradley." There are also a few alluvial fossickers in the district.

"Mount Bradley."—This mine is situated on a conspicuous hill rising some 200ft. above the surrounding country. The auriferous quartz reef forms the crest of the hill, and outcrops to a height of 5ft. to 10ft.

This quartz reef has the characteristics of a true fissure vein. It has a regular strike parallel to that of the surrounding sedimentary shales and sandstones. The dip is also regular and parallel to that of the country rock, being about 3 in 100 to the West. There is a well-marked hanging wall, striated in places, and with a rolling contour. The country rock on this wall is much broken and decomposed, forming a flucan, or "dig." The movement has evidently taken place in the plane of this wall. The reef is from 10ft. to 15ft. wide, and is composed, for the most part, of white quartz, poorly mineralised. There is a vein of a much better appearance between this large vein and the country on the hanging wall. This vein is only from a few inches to half an inch wide; and, towards the north end of the workings, disappears altogether. The tunnel, which is at present being used for working the mine, penetrates the western side of the hill, and is some 300ft. in length. It passes through a yellowish micaceous sandstone, interbedded with narrow bands of yellowish shale. This sandstone forms the western or hanging wall of the reef, the footwall consisting of a yellowish, greasy shale, penetrated by a mass of leaders running from the main reef.

This tunnel intersects a shaft (No. 1) (*vide* Plate 1, Fig. 3) at a depth of 115ft. from the outcrop. This shaft is continued to a depth of 96ft. below the level of the tunnel. It was impossible to

get down the shaft more than 40ft. below the tunnel level owing to a stage and tram rails being laid over it. I was shown some of the quartz from the bottom level, which was coated with a lustrous black graphitic shale. One piece of quartz from the bottom of this shaft contained a very large proportion of iron pyrites. An assay of this gave a result of—tellurium, *nil*; gold, trace; silver, 3dwts. 6grs. per ton.

From the tunnel level there are two drives North and South of 60ft. and 40ft. respectively. A good deal of stoping has been done between these drives and the outcrop of the reef. The main reef outcrops in several places, the first being some 400ft. North of No. 1 shaft. Another reef, outcropping near this, should junction with the main reef somewhere in the locality of the tunnel.

About 100ft. South of the main shaft a shaft (No. 2) (*vide* Plate 1. Fig. 3) has been sunk on the floor wall of the reef to a depth of 123ft. The reef has been stoped out from a drive at the bottom of this shaft to the outcrop for a length of about 30ft., and a width of about 2ft. I was informed that this was good stone. Work has been discontinued here, but it is the intention of the management to connect these workings with the south drive from the main shaft. Some 60ft. South of No. 2 shaft the hill slopes down sharply to the level of the surrounding valley.

A third shaft (No. 3) has been sunk on a small reef 18in. wide. This vein should be close to the hanging wall of the main reef.

The published crushing returns from the "Mount Bradley" are —1,971 tons for 1,579ozs. of gold previous to 1897, and 70 tons for 34ozs. in the first half of 1897.

From the tunnel level in the main shaft to the bottom the shaft has been sunk by the aid of the Government bonus for deep sinking. This depth is 96ft., or a total depth of 211ft. from the surface.

This mine is well provided with crushing appliances. A 10-head battery, worked by a portable engine, is erected, and has been in use for some years. The boxes are somewhat worn, but if the plates and blanket tables were kept in order, and either Berdan pans or amalgamating barrels provided, good results should be obtained. Even with the present appliances assays of the tailings gave results of only 8dwts. 4grs. and 2dwts. 10grs. of gold per ton.

A Wheeler's pan has been used for supplementing the battery amalgamation. On retorting the amalgam from this pan a black mass, containing 95 per cent. of metallic iron, resulted. This must be derived from chips of metallic iron from the shoes and dies, or from excessive grinding in the Wheeler's pan. A battery of 15 heads lies unerected on the ground. A good supply of water has been struck, which, according to the manager, would keep 10 heads working for 16 hours in the 24.

"Golden Crown."—This is another mine in which the Government bonus was utilised to sink below the 100ft. level. The mine is situated about $2\frac{1}{2}$ miles North of the "Mount Bradley." Like all other mines at Brockman's, with the exception of "Mount Bradley," it is now abandoned, the machinery having been removed to the latter mine. Portion of the workings being inaccessible, I had to depend upon the former owner for much of my information. The auriferous vein runs in a North and South direction, and has an average width of about 2ft. The country rock, consisting of the usual shales and sandstones, strikes North-North-East. The walls of the reef consist of a decomposed sandstone penetrated in every direction by a network of leaders running from the reef. Higher up the hill on which this reef outcrops, and some 20ft. to the West, is seen a prominent mass of white barren quartz, evidently forming portion of a main reef which is seen cropping out on a neighbouring hill. The general strike of this main reef is North-North-East parallel to the shales and sandstones. The probability is that there is a main fissure running with the country. In this there are several large quartz veins developed, mostly barren, one of which, however, of a comparatively small width, has been proved auriferous. This, the "Golden Crown" reef, touches the walls of the fissure on neither side. This could be proved by putting in an East and West cross-cut from the bottom of the main shaft. The quartz is of a bluish colour, and contains a small amount of galena and iron pyrites. On either side of the main shaft the reef has been stoped out for a length of 60ft., and for a depth of 70ft. At the 100ft. level a drive 23ft. long has been put in to the South. I was informed that the reef is here 30in. wide, and the stone worth 26dwt. per ton. At the 100ft. level a large quantity of water was struck, and work was discontinued. Twenty-nine feet of the shaft was sunk by Government aid. The published crushing returns are —1,148 tons for 1,389ozs. previous to 1897, and $5\frac{1}{2}$ tons for $6\frac{1}{2}$ozs. in the first half of 1897.

"Faugh a Ballagh."—This mine is situated about a mile North of the "Golden Crown." It has been abandoned for some time. The

reef consists of a small quartz vein running North-West and South-East across the strike of the country which here, as in other parts of the field, is North-North-East, and consists of highly inclined sandstones and shales. The quartz is white or iron stained. No mineral could be found in the quartz obtained except a little galena and dendritic markings of manganese. The stone was examined for tellurium, but no trace was present. The reef is without doubt a segregation vein. The Government bonus was utilised to sink the shaft from the 100ft. level for a depth of 25ft. The published crushing returns are 6 tons for 6ozs. previous to 1897, and 9 tons for 11ozs. in the first half of 1897.

The "Lady Margaret" mine consists of some workings on a cross leader which intersects a dyke of hornblendic rock, probably a diorite. This dyke has the same strike and underlay as the surrounding sandstones and schists, which are here highly indurated. The leader has a strike of West-North-West, and a steep dip to the South, and varies in width from 6in. to 2ft.; but at this greater width the stone is poor. The stone has been stoped out on either side of the dyke for a length of about 40ft., and a depth of from 25ft. to 55ft. The stone gives out, going East, and the gold going West. Small veins of calcite can be seen on either wall of the leader. The dyke is some 10ft. wide, and on its West side a quartz reef runs North and South in contact with the dyke on the East, and the shales and schists on its West. On the East side of the dyke the country consists of an indurated micaceous sandstone. The crushing returns were—97 tons for 252ozs. previous to 1897. No work has been done on this mine for some years.

RUBY CREEK.

This field is situated some 12 miles beyond Brockman's. The same character of rocks appear here as at Hall's Creek and Brockman's, but there is a much larger proportion of sandstone to the clay rock or shale. This shale appears often as a true slate in bands from 1in. to 4in. in thickness, and 2ft. to 3ft. apart, the interstratified rock being a yellow to brown micaceous sandstone. These slates and sandstones strike in a North-North-Easterly direction, and have a highly inclined dip to the East or West. A conspicuous felsite dyke, similar in appearance to that at Hall's Creek, rises prominently as the crown of a well marked succession of ranges trending in a North-North-Easterly direction. The main break in the country caused by this line of felsite dykes seems to be closely connected with the fracturing of the country rock, and the deposition of the gold, as in four of the centres at least it is found in close

proximity to the auriferous veins. The two most important mines at Ruby Creek, and the only two which have not been abandoned, are the "Ruby Queen" and the "St. Laurence."

The outcrop of the "Ruby Queen" line of reef can be traced as the noticeable crest of a North and South range of hills for a distance of three miles. This extensive reef has been worked in the following mines from South to North:—"Ruby Queen," "Ruby Queen No. 1, No. 2, No. 3, No. 4 (West and Left), No. 5, No. 6, No. 7." The best stone was obtained in the "Ruby Queen No. 4 and No. 7." The reef throughout would average about 3ft. in width. The workings in the West and Left are on a cross reef, the junction of which with the main reef has not yet been exploited. Nearly all the work done on Ruby Creek has been confined to the "Ruby Queen" line of reef, the "St. Lawrence" being the only mine of importance off the line.

All the mines mentioned above have been abandoned with the exception of the "Ruby Queen." More work has been done on this mine than on any other on the Kimberley Goldfield, and it has been well opened up. It has been worked mainly by two tunnels (*vide* Plate 2, Figures 1 and 2) running North and South along the reef from a precipitous gully. The outcrop of the reef rises to a height of from 130ft. to 200ft. above this level. The North tunnel is 305ft. long, the South tunnel 155ft. The main shaft, on which is erected a whim, intersects the South tunnel 47ft. from the surface. From the tunnel level the shaft has been sunk 204ft., making a total depth of 247ft. From the 100ft. level to the bottom of the shaft the sinking was accomplished with the help of the Government bonus, 64ft. being sunk in 1895 and 87ft. in 1896. The reef varies in width from 12in. to 8ft., the average being about 3ft. The quartz is of a dark blue colour where richest, and contains vughs full of an impure hematite. Most of the good stone is next the walls, but sometimes the gold is found disseminated throughout the reef. There is not much mineral in the stone, except in places a little iron pyrites. The gold is fine. The reef has well marked walls, especially the eastern one. There seems little doubt that this is a fissure reef. The walls are well defined, rolling, and striated. A "flucan," or "dig," is found between the reef and the country rock. The country rock consists of a micaceous sandstone, with thin layers, 1in. to 2in., of bluish slate. The East wall of the reef consists of sandstone, the West of slate or shale. The stoping done in this mine is extensive, as can be seen from the accompanying sketch. The crushings from these stopes varied in value from 12dwts. to 17dwts. The underlay is steep, and as will be seen from the accompanying sketch, varies from East to

West, in each case conforming with the dip of the slates and sandstones. At the bottom of the shaft a cross-cut has been put in to the West, and at a distance of 25ft. cut the reef, which was here broken up into a number of small veins, separated by bands of graphitic shale containing crystals of iron pyrites.

The largest battery on the field is in connection with this mine, but is, unfortunately, at a distance of about a mile from the workings. It consists of 20 heads, in four boxes, made by Langlands of Melbourne. The boxes are in a fairly good condition. There are two engines on the ground, the larger one being of sufficient power to drive the 20 heads. The battery is provided with amalgamated copper plates and blanket tables. The screens used have 240 and 280 holes to the square inch. The crushing returns, were—6,000 tons for 4,500ozs. previous to 1897, and 67 tons for 31½ozs. in the first half of 1897. There are now more than 100 tons ready to be crushed.

The "St. Lawrence" has been worked until recently. The reef has a remarkably irregular strike somewhat in the shape of an inverted S. The shales forming the casing of the reef seem to conform with this strike, but how far this extends into the general mass of the country rock it is impossible to say without a long and careful examination. Sandstones having the usual North-North-Easterly strike outcrop as shown on accompanying sketch. The reef has an average width of about 3ft. The quartz contains but little mineral, and is of a dark blue colour. It has not been stoped to a greater depth than 70ft., but the average results have been very good. The stone is richer where the reef is smaller, especially in the smaller horse-shoe shown on the sketch. From the bottom of the main shaft, 105ft. deep, an East cross-cut was put in to cut the reverse leg of the reef. It was found broken into a number of small veins, and poor. The stone to the North of the tunnel is also poor, and has not been worked. From the crushing returns it will be seen that the result is the best ever obtained on the Kimberley Goldfield from a large body of stone, 1,275 tons yielding 1,498ozs. previous to 1897, and 102 tons 91ozs. in the first half of 1897.

MARY RIVER.

This locality, which lies 16 miles South-West of Ruby Creek, is quite deserted. But little work has been done here. One shaft has been sunk on a narrow vein of calcite, interbedded with micaceous hornblendic schist. The whole has a North-North-Easterly strike, and is highly inclined. The shaft was sunk to some depth on the underlay, but the stone was only payable near the surface.

On the "Reform" mine a trench has been opened for a length of 60ft., and a depth of 20ft., showing a reef 2ft. to 3ft. wide. The quartz is very poorly mineralised; small veins of calcite run in the direction of the reef. The shaft is filled with dirt and water to within 30ft. of the surface. The published crushing returns were —399 tons for 229ozs. previous to 1897. There is a good 5-head battery on the Mary River, about half a mile distant from the "Reform" mine. The battery is in good preservation, and has been driven by a double-cylinder portable engine. A Wheeler's pan is also on the ground.

MOUNT DOCKRELL.

Mount Dockrell is the most outlying portion of the Kimberley Goldfield, being close to the edge of the Great Desert, and some 50 miles from the Mary River in a Southerly direction. Quartz mining on this field has been abandoned for years, but a few alluvial fossickers visit it at intervals. The geological formation is much the same as on other parts of the field, consisting of highly inclined beds of sandstones alternating with beds of shale passing into slate and mica schist; the whole striking North-North-East. There is a large proportion of mica in the sandstones and slates, and the quartz also contains mica in places. Very little work has been done on this field, and it has revealed only small veins of quartz interbedded with the country, in some places carrying gold, but only to a shallow depth.

In one claim, "McNeill's," some very good stone was obtained, 40 tons yielding 352ozs. This was all obtained within about 15ft. of the surface. The shaft was continued to a depth of 50ft. or 60ft., but nothing below this level was payable. This shaft has been filled up by dry-blowers. The stone at the lower depth contained a large quantity of galena, which gave an assay result of 9ozs. of silver per ton, and a trace of gold; no tellurium could be found.

The adjacent mine, the "Victoria," obtained a portion of this shoot of gold a few feet from their boundary with "McNeill's." Their return was 123ozs. of gold from four tons of stone. A vertical shaft, 25ft. to the East, was sunk with the intention of cutting the reef, but after penetrating a dyke of diorite containing a very large proportion of hornblende, work was discontinued at a depth of 25ft. Several cross trenches have revealed this reef at a distance of a few chains North and South. The stone is white and unmineralised, and no work has been done at these trenches other than exposing the reef. The reef throughout, as far as could be seen, would average about 12in. in width.

Near these mines a light 5-head battery is lying unerected. A good portable engine and a stone-breaker are also on the ground.

The supply of timber is poor, and surface water is also unreliable. Water has not been struck at a depth, the workings all being shallow.

The "Black Prince" is another abandoned mine in this district, and the shaft is now filled up within 15ft. of the surface. As far as could be seen the shaft was sunk on a series of small parallel veins interbedded with decomposed slates or shales.

PANTON RIVER.

This portion of the Kimberley Goldfield is situated at the extreme North end of the known auriferous country. It is some 42 miles in a North-North-Easterly direction from Hall's Creek. A fair amount of work has been done here, but all the mines, with the exception of two, the "Star of Kimberley" and the "Nil Desperandum," are now abandoned. Most of the country consists of a plain covered in places with a considerable depth of black alluvium. One of the high felsite-backed ridges appears some miles to the West, and some low hills are seen to the North-East. A slight rise of about 10ft. above the plain exhibits the outcrop of a quartz reef which can be traced for about a mile. This outcrop conforms in strike with the country rock, which here consists of the usual sandstones and shales. A cluster of mines, the "Comet," "Caledonian," "Lone Hand," etc., lie near the low hills to the North-East. The "Lone Hand" has just been abandoned, and the shaft is now full of water. The others have been abandoned for years, and the workings have fallen in. There is no battery on the Panton River, a good 5-head battery having been removed to the Mary River.

The "Star of Kimberley" after having been abandoned for years was again taken up while I was on the field, and I obtained a sample of stone broken by the first shot put in after the resumption of work. This stone contained a large proportion of galena. An assay gave a result of—tellurium, *nil*; gold, 3dwts.; silver, 12dwts. The workings consist of three shafts, two of which are 30ft., and one—the only one now being worked—70ft. deep. The reef is 3ft. to 4ft. wide, and has been left standing for 20ft. in the shaft. The only published crushing return from this mine is one ton for 16dwts. I had not enough opportunity of determining whether this is a fissure reef, but there seems a probability of its being so. The "Nil Desperandum," another mine now being worked, consists of a shaft 30ft. deep on a quartz leader 1in. to 3in. thick, running into a main line of reef on which the "Star of Kimberley" is situated. This shaft is only 15ft. from this main line. Some rich stone was obtained from this leader, but the shoot was only about 5ft. long, and seems to be related to a vertical fault which causes a slight displacement of the leader and the surrounding country. This stone was examined for tellurium, but no trace was present.

The "Lone Hand," situated some two miles North-East from these mines, has just been abandoned. The reef consists of a quartz vein about 14in. thick, interbedded with the country. A shaft has been sunk for a depth of 60ft. From the surface to a depth of 16ft. some 260oz. of gold were obtained, but in the next 44ft. of the shaft not even a trace could be obtained. At this lower level the reef consists almost wholly of galena, which, on examination was, found to contain—tellurium, *nil*; gold, *nil*; silver, 26ozs. 12dwts. per ton. The country rock is a greenish schist, much decomposed, and not highly laminated. The shoot of gold is wedge-shaped, the greatest width being 15ft.

GENERAL SUMMARY.

It will be gathered from the foregoing description of the various mining centres on the Kimberley Goldfield that very little work has been done, except on a few mines, since the visit of the Government Geologist in 1891.

The following table shows the total recorded crushings since the discovery of the field:—

CRUSHING RETURNS.

Mines.	Previous to 1891.		1891 to 1897.		First half 1897.	
	Tonnage.	oz. dwt. grs.	Tonnage.	oz. dwt. grs.	Tonnage.	oz. dwt. grs.
Mount Bradley	789	810 9 15	1,182	768 8 15	70	33 16 0
Golden Crown	1,000	1,250 0 0	148	139 10 4	$5\frac{1}{2}$	6 11 0
Ruby Queen	2,000	1,500 0 0	4,000	3,000 0 0	67	31 10 0
St. Laurence	233	277 10 0	1,042	1,220 9 12	102	91 0 0
Brockman King	...	...	24	17 17 8	61	21 7 0
Right Bower	...	...	..	...	5	3 0 0
Rose	...	...	...	...	64	30 18 0
Faugh-a-Ballagh	6	6 5 0	...	...	9	11 4 0
Lone Hand	...	...	..	260 0 0		
Jubilee	$9\frac{3}{4}$	103 13 12	$13\frac{1}{4}$	87 0 0		
Comet	$1\frac{3}{4}$	134 0 0	$26\frac{1}{4}$	13 6 20		
Afghan Crown	64	48 8 0	30	26 2 0		
Union	30	45 10 0	57	62 9 0		
West and Left .. .	189	376 18 0	490	657 1 0		
Rising Sun	500	437 0 0	77	98 6 0		
Sunny Corner . .	20	60 0 0	2	4 11 12		
Reform	$3\frac{1}{4}$	11 0 0	396	217 17 0		
Star of Kimberley ..	1	0 16 0				
Perseverance	5	3 0 0				
Lady Broome	400	30 0 0				
Do. No. 1 N. ..	6	4 3 0				
Gladstone	2	3 17 0				
Jackson's Reef	78	56 18 0				
Black Mount	$8\frac{1}{2}$	3 8 0				
Lady Margaret ...	97	251 14 19				
Do. No. 1 N.	20	16 6 12				
Do. No. 5 N.	$6\frac{1}{2}$	9 6 0				
Southern Cross	5	3 5 0				
McNeill's	40	351 14 0				
Victoria	4	123 6 0				
Total	5,519	6,218 8 10	7,487	6,572 19 9	$383\frac{1}{2}$	299 6 0
Average value ...	...	1 2 12	...	0 17 12	...	0 12 0
Number of Mines crushing	...	26	..	14	...	8

Present number of mines working, five,

The cause of this stoppage of all but a few mines is almost invariably due to the stone at a comparatively shallow depth becoming too poor to work. Water for domestic and mining purposes is plentiful. Fuel and mining timber are fairly abundant, and, although the cost of carriage of goods from the coast is heavy, still living is no more expensive than on many portions of the Southern fields which are now being worked. Wages are £4 per week.

The abandoned mines, with one or two exceptions, are in a most dilapidated state. The wood-work of the shafts has decayed and fallen in in many cases, and in others the shafts are full of dirt and water. Comparatively few mines could therefore be carefully inspected.

The country, as has been mentioned above, resembles somewhat the older Silurian country, in which many of the Western goldfields of Victoria are situated. It is impossible, however, to deduce from this resemblance that the Kimberley gold reefs will resemble that of Victoria; for in Victoria itself much of the country in which the reefs are perfectly barren resembles in every detail the country in which the rich auriferous reefs occur.

A portion of the Pilbarra Fields, which I passed over very rapidly, resembles the Kimberley country; but there is a wide difference between the Kimberley Field and the Southern Fields of this Colony. The difference is nowhere greater than between Kimberley and the Kalgoorlie Field, where telluride of gold is being profitably mined in this Colony.

In the latter field the lode material itself consists of a schistose hornblendic rock, probably metamorphised dyke material. There is no parallel to this in the Kimberley Fields.

In considering the value of auriferous quartz reefs two points must be carefully studied :—

1. The continuance in length and depth of the quartz reef.
2. The continuance in length and depth of the shoot of gold.

The quartz reefs of Kimberley can, for my purpose, be classed under two heads :—

1. Fissure veins.
2. Segregation veins.

The ordinary characteristics of fissure veins have been described above. Segregation veins continue for a comparatively short distance and depth ; they may run with the country or across it, but in either case are highly unreliable, and in no case could be regarded as forming a mine. The known auriferous veins of the

Kimberley Field belong, with one or two exceptions, to this class. These exceptions, which are fissure reefs, have been named above. Such reefs can be relied upon to continue sometimes for miles in length, and for thousands of feet in depth.

Many of the segregation veins of the Kimberley Goldfield, as can be gathered from the preceding description, have yielded small patches of highly payable stone. These patches, however, have almost invariably given out at a very shallow depth, as may be observed from studying the table of crushings given above. This can also be observed from the nature of the workings on the mines, character of the stone, etc.

There has been fairly good alluvial gold obtained in parts of the Kimberley Field, and this, although necessarily derived from quartz reefs, does not therefore predicate that these reefs are payable, for three reasons :—

1. The quartz reef from which this alluvial gold is derived may be too small to be payable.
2. Nearly all, or all, of the gold-bearing portion of the reef may have been denuded, and only the barren portion left.
3. The gold may have become concentrated in the alluvial leads in which it has been found.

So we find that in Kalgoorlie some of the best alluvial gold was obtained on the Western slopes of the hills from "Hannan's Reward" and "Maritana Hill." This was almost certainly derived from small quartz veins dipping into these hills.

Little need be said with regard to the best system of ore treatment to be adopted on the Kimberley Goldfield. In considering this three points must be observed:—

1. Nature of gold.
2. Nature of lode stuff.
3. Accompanying minerals in lode stuff.
    1. The gold is generally of an average size, but in a few cases is moderately fine.
    2. The lode stuff is quartz.
    3. The accompanying minerals are small quantities of iron and arsenical pyrites, oxides, carbonates and sulphides of copper, and, in several cases, a large quantity of galena.

The lode stuff could not be more suitable for ordinary battery treatment. The fineness of the gold in places, and the large quantities of galena in others, need consideration.

To save such fine gold, fine battery screens, well-kept copper plates and blanket tables, the blanketings being treated in Berdan pans or amalgamating barrels, is all that is necessary. If the galena occurred commonly with the rich stone its presence would occasion some difficulty; but it is a peculiar fact that the galena, as a rule, is only present in large quantities in a reef after the rich stone has given out. This galena, as has been stated above, contains a little silver, and generally a trace of gold.

In the exceptional case where a large quantity of galena occurs in rich stone, the stone should either be sent away for treatment to some smelting works, or, if it be not rich enough to warrant this, a frequent cleaning of the plates, and the use of sodium amalgam to prevent sickening of the mercury, is all that can be done. A certain loss of gold will result, but this cannot well be obviated on a small scale.

The retorted gold will, of course, contain a large quantity of lead, but this can be easily removed by sending the retorted gold to smelting works, or to the mint.

Samples of stone were taken from all parts of the field, but no trace of tellurium could be found. As has been stated above, the geological character of this country is very different to that of Kalgoorlie, where there is such a valuable deposit of tellurides of gold, and the field is no less different to the other portions of the world where tellurides of gold are found in payable quantities, such as Mount Morgan, where it occurs in a contact lode between Permo-Carboniferous shales and dolerite; Cripple Creek, Colorado, where the lodes occur in phonolite, andesite breccia, and in granite, and other parts of America where it occurs in gneiss. The fact that tellurides of gold are very rare minerals, only found in payable quantities in three or four parts of the world, combined with the fact that in the nearest of these, Kalgoorlie, the lode occurrence is of an entirely different character, would point to the conclusion that there is little probability of tellurides of gold being found in payable quantities on the Kimberley Goldfield.*

Traces of tellurium are said to have been found recently in one of the Victorian goldfields, and so traces may be found at some time in the Kimberley field, but there is no indication to that effect.

The Government bonus for deep sinking below the 100ft. level has been used in the case of seven mines. Three of these mines were of fair promise. In such cases the use of the bonus might have demonstrated the existence in depth of payable stone. If the stone had been payable it would have led to increased sinking, not

*That is over the small portion which has already been explored. A.G.M.

only in these mines, but in many other parts of the field. Unfortunately the stone became poorer in depth.

In the case of the other four mines there is no doubt that the bonus was misapplied, the reefs being of small width and uncertain continuance both in length and depth. The only use of the bonus in such cases is to enable miners to earn good wages. A Government bonus for sinking should *only be granted in order to demonstrate something not already known*, in this case the continuance or non-continuance in depth of payable stone on the Kimberley Goldfield.

In the three cases mentioned above it seems a wise thing to have granted it, but now that so many of the mines of the field have become poorer in depth, the aid, if given at all, should only be given after careful recommendation by a trained mining engineer,* as is done in some of the Eastern Colonies. In any case there seems to be no reason why the bonus should be given on this field more than on many portions of the Southern goldfields.

The past history of this field will, I think, be the future history of the field. Patches of alluvial gold, and small veins of uncertain continuance, will be found at rare intervals, which will pay working shareholders well for a few months.

The finding of main fissure reefs, containing payable stone, is much more unlikely. The prominent outcrop of such a reef on the bare Kimberley hills would have led to its discovery years ago. This probable future of the field, combined with its past history, point to but one conclusion, *i.e.*, that the field is not suitable for large companies, but for the gaining of a precarious living by working miners.

R. NEIL SMITH,
Mining Engineer.

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* Or other scientifically trained officer. A.G.M.

2.—The Probability of obtaining Artesian Water between the Pilbarra Goldfields and the Great Desert.

From Roebourne to Condon, a distance of 210 miles, the country consists of flat plains of sand, clay, and beds of shingle, with a few local intrusions of hornblendic rock, probably diorites.

From Condon to the De Grey station, and along the De Grey River to a distance of about 100 miles from the coast, the country consists of a like series of plains with a gradual rise of between 100ft. and 200ft. Some 90 miles from the coast there is a North and South range of porphyry, and close to the East side of this an outcrop of granite extending in a few low hills to a distance of about 10 miles North of the river. At a distance of 100 miles from the coast a prominent range is cut through by the river. This range consists of two parallel ridges about half-a-mile apart, and rises to heights varying from 100ft. to 400ft. above the level of the river.

Owing to a storm of wind and rain which compelled me to push on for shelter some 40 miles further East, the exact nature of the rocks forming this range could not be determined. It consisted of a series of hills stretching in a North and South direction for about 10 miles North of the river, and then turning East and West as shown on accompanying sketch map. These hills were flat-topped and broken by frequent abrupt gorges. The crest of the range consisted of a horizontal stratum of a highly indurated rock; the lower strata being so much softer as to have become weathered away, leaving a succession of small caves some 10ft. to 20ft. from the summit of the range. This range crosses the river and proceeds in the direction of Bamboo Creek.

The two parallel ridges forming this range, and the valley between them, occupy a strip of country about a mile wide. They rise abruptly from the plains, and form at this point the Western boundary of Warrawagine Station.

Some five miles East of this range gneiss and granite begin to outcrop, and continue to the junction of the Nullagine River with the Oakover. The Eastern branch of the range mentioned above

can be seen in the distance as a series of isolated flat-topped hills stretching Eastwards to the edge of the Great Desert.

From the junction of the rivers onward to the Warrawagine Homestead, and for five miles beyond, a total distance of 20 miles, the country is flat and covered with beds of clay, sand, and gravel, and in a few places with "cement."

Five miles South of the homestead a low irregular series of limestone hills make their appearance. These hills are all of small extent, and are dotted in all directions over the strip of country between the Nullagine and Oakover Rivers. The summit of nearly every hill is, to the eye, perfectly horizontal, due to horizontal beds of silica, which have protected the underlying beds of limestone from denudation. The flats between these hills consist of limestone, with here and there small stretches of bean-shaped ironstone pebbles. This belt of limestone country is bounded on the East by the Oakover River, crossing it only for a very limited area 10 miles South of Braeside Station. High cliffs of crystalline limestone appear on the West bank of this river at Carawine Pool and Tooncoonarlagee, about 100 miles South of the junction of the Nullagine and Oakover.

From the base of these cliffs springs of water, highly charged with lime, issue and flow into the Oakover. At Tooncoonarlagee the supply must be many thousands of gallons per day. Similar cliffs are seen on the Little River, and on the "Nullagine Gorge," where a large mass of ironstone breccia also appears. According to the geological map published by the Department of Mines in 1894, this limestone extends South and West for hundreds of miles.

Some four miles East of the Oakover River, and running approximately parallel with it, a prominent range rises abruptly from the surrounding alluvial plains. This consists, where inspected, of an amygdaloidal melaphyre, the exact nature of which it was impossible to determine owing to the decomposition of the exposed rock. This range is from 200ft. to 400ft. above the bed of the river, and extends for a distance of many miles, skirting the greater portion of the Eastern boundary of Warrawagine.

Five miles West of the Nullagine River there is a series of low granite and gneissic rises extending to within 10 miles of Bamboo Creek. This, probably, is a continuation of the granite outcrop appearing on the North side of the De Grey River.

Some seven miles East of Bamboo Creek some beds of indurated sandstone make their appearance. They have a dip of about 20° to the East, and rise about 80ft. above the surrounding country. At

Bamboo Creek itself a great dyke of felspar and quartz porphyry occurs.

I was not able to see the country South of Bamboo Creek and West of Warrawagine, but it consists, I believe, of low granite hills and rises, except where the auriferous belt of Bamboo Creek penetrates it.

Many wells have been sunk along the banks of the De Grey River and on Warrawagine and Braeside Stations. In most cases a plentiful supply of fresh water was obtained at a depth of from 20ft. to 40ft. In one place, five miles East of the junction of the Oakover and Nullagine, on the edge of the desert, salt water was struck after passing through a layer of "cement" consisting of a decomposed dolomite.

At Braeside a well sunk to a depth of 32ft. furnished a plentiful supply of water after penetrating the following strata:—

	ft.	in.	
Red Clay	30	0	
Cement	0	6	
Loose Gravel	0	6	(carrying water.)
Pipe Clay	1	0	
	32ft.		

At Warrawagine a well was sunk, and, after penetrating about 40ft. of clay, water was obtained in a bed of gravel overlying cement.

In order to obtain an artesian water supply in any locality the following conditions must be present; the absence of any one of them preventing a supply:—

1. An upper layer of impervious material.
2. A layer of freely porous material.
3. An under layer of impervious material.
4. The continuity of these three layers on to some high ground.

The nature of this high ground must be as follows:—

(*a.*) The upper impervious layer must continue to such a height as to give a head of water sufficient to overcome the resistance of penetrating the porous layer and of rising in the bore to the surface in sufficient quantity.

(*b.*) The porous layer must rise to an equal or greater height.

(*c*.) The lower impervious layer must be higher than this again, and must be of sufficient superficial extent to give a constant supply of water at the locality of the bore. This extent is of course dependent on the rainfall.

My examination of the district was very hurried, but it enabled me to form an opinion with regard to the absence of the above conditions.

1. An upper layer of impervious material covers the country wherever inspected, except over a few patches of granite.
2. A porous layer is doubtless present in most places, but is generally only a few inches in thickness, and consists of loose beds of gravel. These beds are probably not continuous for a great distance.
3. Granite doubtless underlies all the country, but in many places must be at a comparatively shallow depth.
4. The upper impervious layers continue on to the higher ground of the plains, but do not rise up the slopes of the ranges. The porous layer is not exposed at the foot of the ranges, nor does it rise on the slopes. As mentioned above, it is probably a series of unconnected beds of small extent. In the case of granite risers, or even of the melaphyre range on the East, the impervious bottom layer was carried on to a height of from 250ft. to 400ft. above the surrounding country. These ranges were, however, of an inconsiderable breadth, and had, therefore, a comparatively small watershed. The annual rainfall in the district is 15in., although 38in. to 42in. have fallen during the late phenomenal season.

A large proportion of this rain-water must penetrate the limestone, as is evidenced by the springs occurring at the base of the cliffs.

The comparatively small superficial extent of the impervious ranges, and the probable want of continuity of the water bearing stratum to this higher ground, are both unfavourable to the probability of obtaining artesian water in this district.

R. NEIL SMITH,
Mining Engineer.

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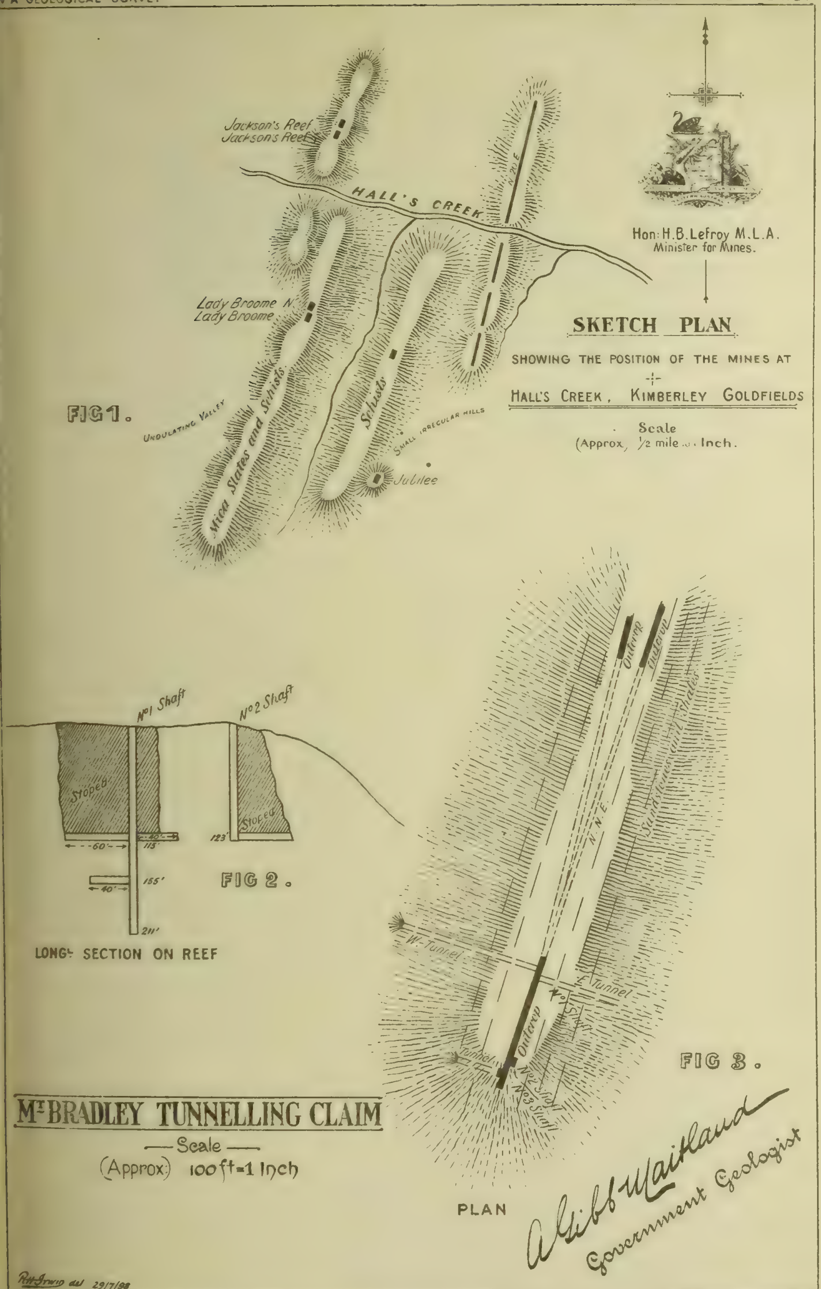

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RUBY QUEEN GOLD MINE

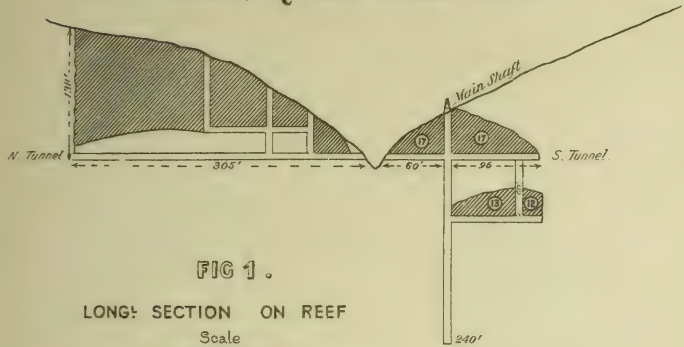


FIG 1.

LONGL SECTION ON REEF

Scale
100 ft = 1 Inch.

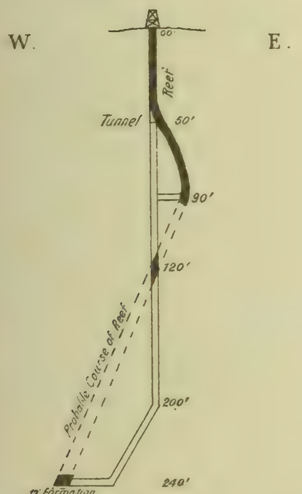


FIG 2.

TRANSVERSE SECTION THROUGH MAIN SHAFT

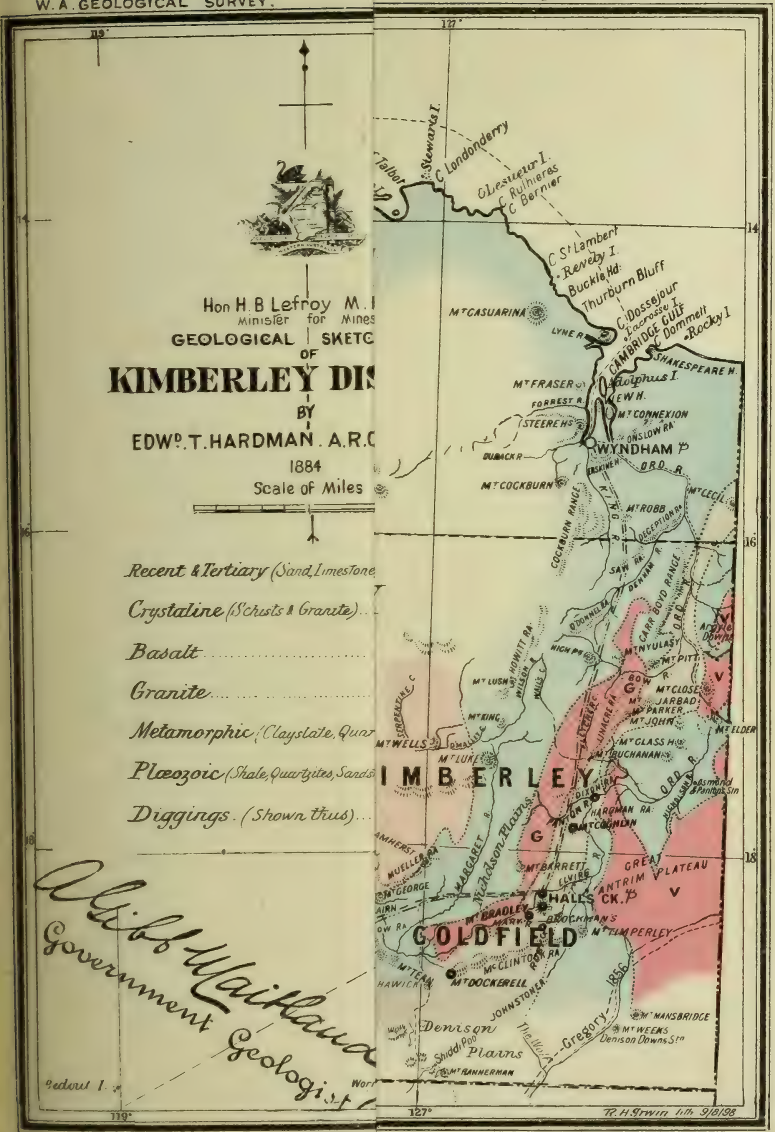
RUBY QUEEN G.M.Cº.

Scale
50 ft = 1 Inch

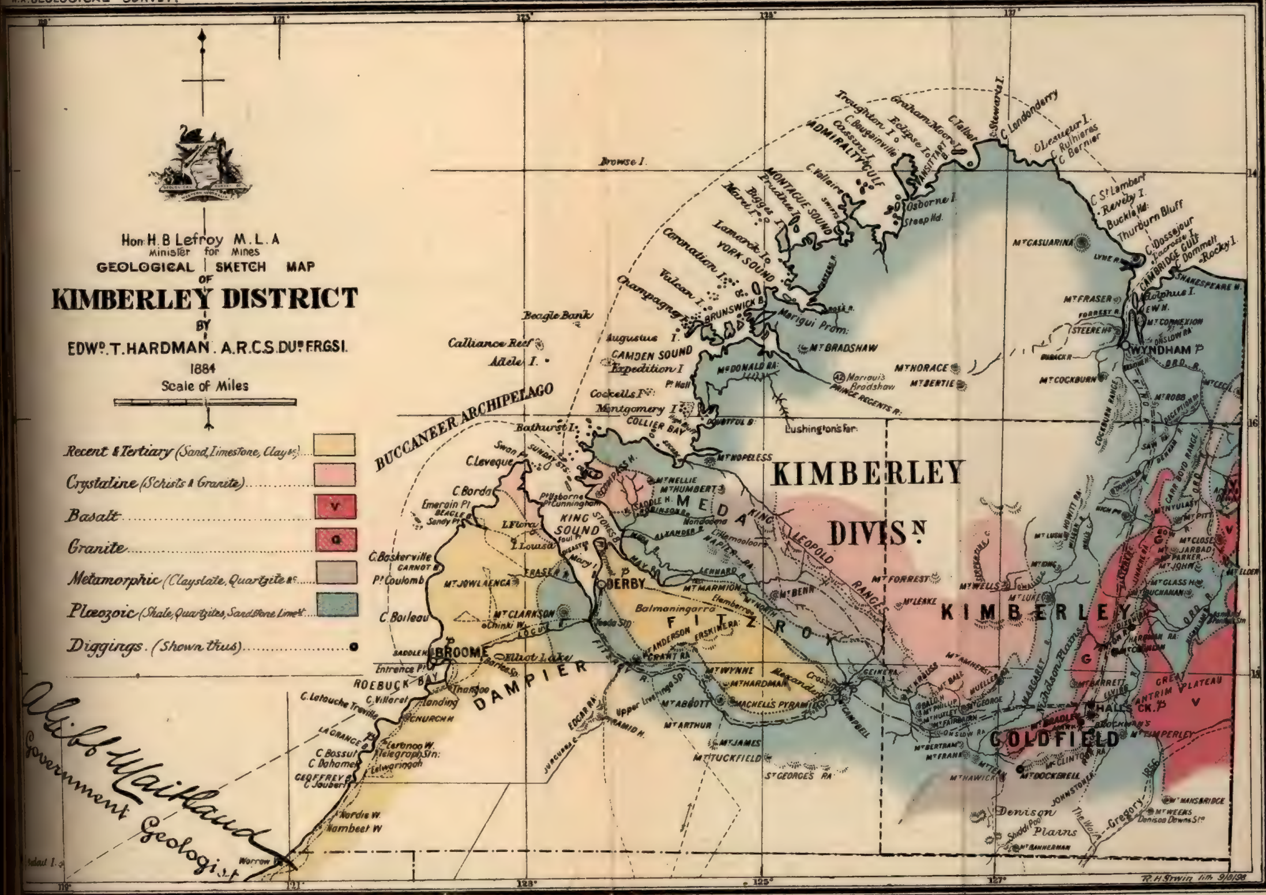
Hon: H.B. Lefroy M.L.A.
Minister for Mines.

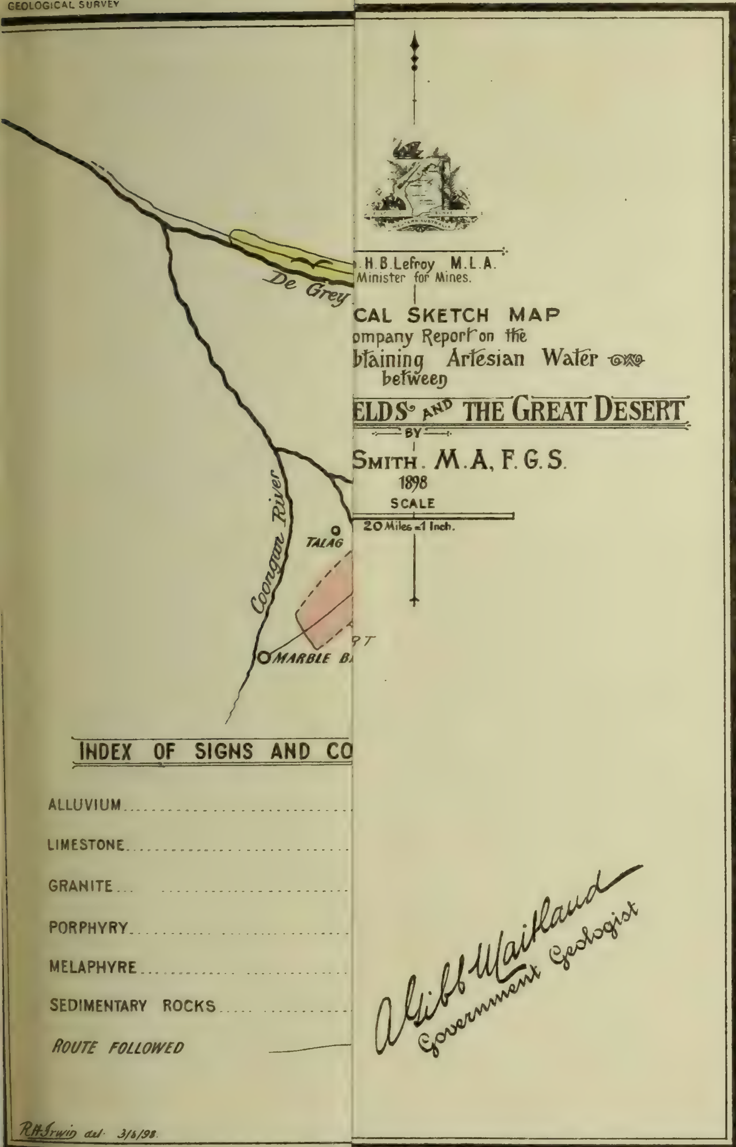
A Gibb Maitland
Government Geologist

RHJones del 29/7/98



Hon H. B Lefroy M.
Minister for Mines
GEOLOGICAL SKETC
OF
KIMBERLEY DIS
BY
EDWD. T. HARDMAN. A.R.C
1884
Scale of Miles
Recent & Tertiary (Sand, Limestone
Crystaline (Schists & Granite)
Basalt
Granite
Metamorphic (Claystate, Quar
Plæozoic (Shale, Quartzites, Sands
Diggings. (Shown thus)
A. Gibb Maitland
Government Geologist
C Londonderry
Stewarts I.
C Lesueur I.
C Rulhieres
C Bernier
C St Lambert
Reveley I.
Buckle Hd
Thurburn Bluff
C Dossejour
Lacrosse I.
CAMBRIDGE GULF
C Dommett
Rocky I
MT CASUARINA
LYNE R
SHAKESPEARE H.
MT FRASER
Adolphus I.
FORREST R
STEERE HS
MT CONNEXION
ONSLOW RA
WYNDHAM
DUNHAM R
ORD R
MT COCKBURN
COCKBURN RANGE
MT CECIL
MT ROBB
DECEPTION RA
SAW RA
DENHAM
CARR BOYD RANGE
O'DONNELL RA
HOWITT RA
HIGH PK
MT NYULASY
MT PITT
Argyle Downs
MT LUSH
WILSON R
BOW R
MT CLOSE
JARBAD
MT PARKER
MT JOHN
MT KING
MT GLASS H
MT ELDER
MT WELLS
MT LUKE
MT BUCHANAN
KIMBERLEY
Osmond & Panton Stn
DIXON RA
HARDMAN RA
MT COGHLAN
AMHERST
MUELLER RA
MARGARET R
Nicholson Plains
MT BARRETT
ELVIRE
GREAT ANTRIM PLATEAU
MT GEORGE
HALLS CK.
MT BRADLEY
BROCKMAN'S
GOLDFIELD
MT KIMPERLEY
McCLINTOCK RA
MT TEAN
MT DOCKERELL
HAWICK
JOHNSTONE
1856
Gregory
MT MANSBRIDGE
MT WEEKS
Denison Downs Stn
Denison Plains
Shiddi Poo
MT BANNERMAN
The Wolf
119°
127°
14
16
18
R. H. Irwin lith 9/8/98


Hon. H. B Lefroy M.L.A
Minister for Mines
GEOLOGICAL SKETCH MAP
OF
KIMBERLEY DISTRICT
BY
EDWD. T. HARDMAN. A.R.C.S. DUB. F.R.G.S.I.
1884
Scale of Miles
Recent & Tertiary (Sand, Limestone, Clays &c.)
Crystaline (Schists & Granite)
Basalt
Granite
Metamorphic (Claystate, Quartzite &c.)
Plaeozoic (Shale, Quartzites, Sandstone Lime &c.)
Diggings. (Shown thus)
KIMBERLEY DIVISN.
KIMBERLEY GOLDFIELD
BUCCANEER ARCHIPELAGO
KING SOUND
DERBY
BROOME
ROEBUCK BAY
DAMPIER
FITZ ROY
WYNDHAM
CAMBRIDGE GULF
ADMIRALTY GULF
YORK SOUND
CAMDEN SOUND
COLLIER BAY
Browse I.
Beagle Bank
Denison Plains
Alfred Maitland
Government Geologist
R. H. Irwin lith 9/8/98



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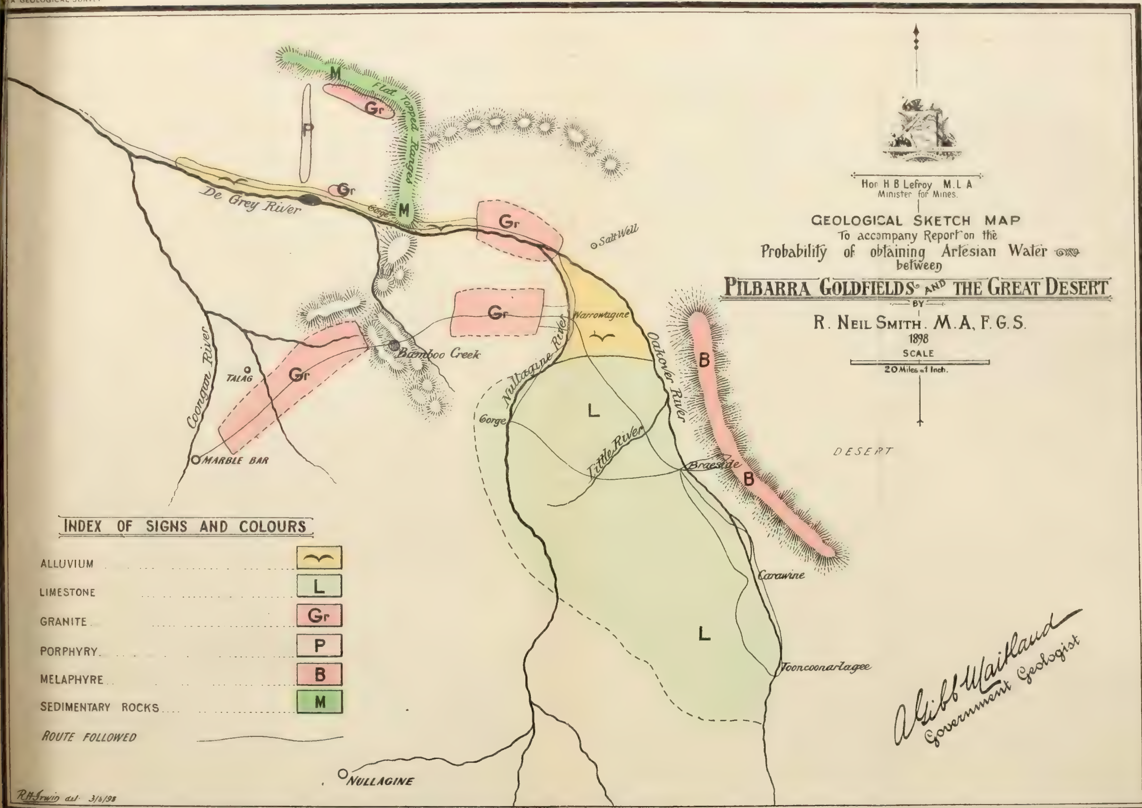
Hon H B Lefroy M.L.A
Minister for Mines.
GEOLOGICAL SKETCH MAP
To accompany Report on the
Probability of obtaining Artesian Water
between
PILBARRA GOLDFIELDS AND THE GREAT DESERT
BY
R. NEIL SMITH. M.A, F.G.S.
1898
SCALE
20 Miles of 1 Inch.
Flat Topped Ranges
De Grey River
Gorge
Salt Well
Warrawagine
Nullagine River
Oakover River
Bamboo Creek
Coongan River
TALAG
MARBLE BAR
Gorge
Little River
Braeside
DESERT
Carawine
Tooncoonarlagee
NULLAGINE
M
Gr
P
B
L
INDEX OF SIGNS AND COLOURS
ALLUVIUM
LIMESTONE
GRANITE
PORPHYRY
MELAPHYRE
SEDIMENTARY ROCKS
ROUTE FOLLOWED
A Gibb Maitland
Government Geologist
R.H. Irwin del. 3/8/98

1899.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 3.

THE GEOLOGY OF THE COOLGARDIE GOLDFIELD,

BY

TORRINGTON BLATCHFORD, B.A., F.G.S.,

ASSISTANT GOVERNMENT GEOLOGIST.

Issued under the authority of the Hon. H. B. Lefroy, M.L.A., Minister of Mines.

PERTH:

BY AUTHORITY: RICHARD PETHER, GOVERNMENT PRINTER.

1899.

TABLE OF CONTENTS.

PREFATORY NOTE.

IN an extensive Colony such as this there are two totally distinct classes of geological survey work necessary to meet the public requirements.

The *first* is the detailed examination of the important mining centres, and comprises the accurate mapping of the geological formations, the accumulation of information relating to the occurrence of the various ore deposits, and their mode of formation. In the search for new deposits, and in defining limits of those already known, the geologist has to be guided to a large extent by a knowledge of the methods by which particular ore bodies have been formed; for it is only in this way that the peculiarities of their distribution can be anticipated and their continuity forecasted. The accurate location of the geological formations, more especially in mining districts, being a practical necessity for their interpretation, the construction of topographical maps is a first essential, and consumes an ever-increasing share of the Geological Surveyor's time, which could well be more profitably employed.

The *second* class of work is the preliminary examination of comparatively unknown tracts of country with the view of ascertaining how far its geological characteristics are likely to affect its possibilities as mineral bearing country. Theoretically this latter work should, as far as possible, be carried out in advance of the occupation of the country for mining or other purposes; the exigencies of the public service, however, do not always admit of this being done, although a great deal can be accomplished in this direction.

Of the former class of work the Geological Survey Department has carried out a detailed examination of the more immediate vicinity of Coolgardie. The mapping of the formations of this goldfield was entrusted to Mr. Torrington Blatchford and Mr. F. L. Allhusen, while to the former member of the staff was allotted the preparation of the descriptive report on the district. The present report embraces not only the original work of the Departmental officers, but includes a brief *aperçu* of the labours of other observers.

A geological map, on the scale of 40 chains per inch, accompanies this report. It is designed more as an index to the four-sheet map, on a scale of 10 chains per inch, which contains many more details than would be possible to show on the smaller map.

In addition to mapping the geological boundaries (a matter of some difficulty in places, owing to the thick cover of recent superficial accumulations), the geologists ran contour lines at intervals of 20 feet over the area embraced by their work. Their labours in this direction were much facilitated owing to the courtesy of F. W. T. Saunders, Esq., the District Engineer of the Goldfields Water Supply Department, who was good enough to place at our disposal the contour survey of the portion of the district lying more immediately in the vicinity of Coolgardie.

The geological character of Coolgardie consists of a mass of intrusive granite on the West, succeeded by a belt of hornblende and talcose schists, the whole being intersected by dykes of diorite (?) and acidic rocks. The dykes follow the strike of the schists, but there are local exceptions to the rule. The acid eruptive rocks in all probability emanate from the main granite mass, as cases occur in which a gradual passage from the latter can be identified. The recent superficial deposits cover a very large portion of the field, and vary in thickness from a few inches up to several hundreds of feet, as in Rollo's bore. In some portions of Coolgardie there occurs, resting on the denuded granite surface, a thin bed of cement of the type occurring at Kanowna and the 25-Mile.

What now remains of this cement occurs in every case at levels between 1,380 and 1,460 feet above sea level, showing that the deposit has a somewhat uniform level. The average thickness of this deposit does not exceed three feet, and although auriferous, it has not, up to the present, proved to be payably so.

The gold obtained from Coolgardie has been derived from three principal sources, viz., alluvial deposits, lode formations, and quartz reefs.

The gold from the recent superficial deposits presents all the usual characters. Unfortunately there are no data available by which the amount of alluvial gold obtained from the Coolgardie Goldfield can be deduced. The "lode formations," as a rule, consist of schistose rocks traversed by a network of quartz leaders; the formations appear to possess no sharply defined boundaries, unless in exceptional cases, the limits of the deposit being defined by purely technical considerations. A great deal of gold seems to

have been derived from these formations, but, owing to the way in which the returns are kept, it has not been possible to separate the yield of formations from that of the quartz reefs proper. The quartz reefs would seem to be practically confined to the schists. The reefs trend generally North and South, and have a dip of from 60 degrees to 80 degrees to the East. The gold occurs in shoots in the reefs, but so far no observations have been recorded as to either direction or the strike of the shoots.

Up to the end of 1898 there have been crushed from the Coolgardie Goldfield 206,211 tons of ore, yielding 242,235ozs. of gold, or at the rate of 1oz. 3dwt. per ton.

The Customs authorities, however, give 521,104ozs. of gold, as being that entered for export from the Coolgardie Goldfield, being 278,869ozs. in excess of the figures furnished to the Mines Department.

The discrepancy may be partly accounted for by the difficulty experienced in obtaining any record of the output of alluvial gold, and also that a good deal of the gold won in the early days of the goldfield was never officially reported to the Department of Mines, and until quite recently deemed worthy of no better record than the ephemeral currency of the newspaper.

A. GIBB MAITLAND,
Government Geologist.

Geological Survey Office,
Perth, 20th March, 1899.

THE GEOLOGY OF THE COOLGARDIE GOLDFIELD.

Introduction.

The object of this report is to place before the public such general geological information of the Coolgardie Goldfield as can be gathered from previous writings on the subject, and any (official) data collected by officers of this and the other Government Departments of this Colony. In addition to such general description, an accurate geological survey has been made of that particular portion of the Goldfield in the immediate vicinity of the Coolgardie Townsite, and notes made on the 25-Mile (Kunanalling) Cement Deposits. Considering the area of the Coolgardie Goldfield, it would be impossible, with the present staff, to carry on a detailed survey for the whole area. It has therefore been necessary to choose the most important mining portions as a basis, to which any future detail work can be subsequently added. Situated in the centre of an auriferous belt of country striking North and South, this area was chosen first for obvious reasons, and though due reference will be made to other parts of the field, a detailed description of this particular portion will occupy most of this report.

The Coolgardie Goldfield.

"The Coolgardie Goldfield at present is bounded by lines "starting from the North-East corner of the Yilgarn Goldfield "(which is a point about 50 miles West from a cairn marked "NB 1, near the Wangine Soak) and extending South about "118 miles through a cairn, H 26, on Koorarawalyee Granite "Rock; thence East about 113 miles through the summit of a "granite rock near the 50-Mile Soak, on the Dundas and Lake "Lefroy Road; thence North about 48 miles to a point 35 miles "East of the South-East corner of the above-mentioned location; "thence along the boundaries (surveyed) of Location 48, Westerly "443 chains 91 links, Northerly 564 chains 87 links to the South-"East corner of Location 51; thence along the boundaries (sur-"veyed) of that location Westerly 160 chains, Southerly 60 chains,

"Westerly 119 chains 87 links to South-West corner of Location "51; thence Northerly 400 chains along the Western boundary of "Location 51 and Eastern boundary of Location 53 to the North-"East corner of Location 53; thence 36 miles 1,481 links along "a surveyed line 324° 46′; thence North 30 miles 47 chains 36 "links along a surveyed line to a tree, R 3, near the Cane Grass "Swamp, on the 90-Mile Road; thence Westerly to a cairn marked "NB 1, near Wangine Soak; thence Westerly about 50 miles "to the starting point, excluding all townsites and fee simple lands "within the said boundaries."

The area included within these boundaries is computed by the authorities to be 11,974 square miles.

Previous to March 20th, 1896, the Coolgardie Goldfield embraced the present Coolgardie, East Coolgardie, North-East Coolgardie and Broad Arrow Goldfields, all of which, together with the present Yilgarn Goldfield, were originally known as the Yilgarn Goldfield.

The Geological Map of part of the Coolgardie Goldfield.

The accompanying map embraces a tract of country extending four miles North and South, and two miles East and West of the Coolgardie Townsite. On it are indicated all shafts and works on the leases, the position, strike, and dip of lines of reefs, and all geological boundaries and topographical features.

Contours at 10ft. intervals have been run out over the whole area, so that the approximate form of the surface of the field is represented. This work was much facilitated through the courtesy of F. W. T. Saunders, District Engineer of the Goldfields Water Supply Department, who was good enough to place at our disposal tracings of the contour surveys made in connection with the water reservoirs to the South of the Townsite.

In mapping out these various boundaries, etc., a Plane Table and Tacheometer were used. The scale of the original plane table sheets was 10 chains to one inch. In addition to purely geological work, its economic aspects, including statistics of gold outputs, water supplies, working plans, etc., are also dealt with in the following report.

It is much to be regretted that the circumstances under which this work has been carried out to effect this object have been some-

what unfavourable, inasmuch as the prospecting has been, as a rule, of a very meagre character, consisting in most cases of sinking shafts, at most, to the water level, or till hard country is reached.

In addition to this, except in isolated cases, reliable working plans have either not been kept or are otherwise unprocurable.

In consequence, much of the field remains unprospected, and covered as it is by thick accumulations of detritus, the boundaries of the various formations, and sometimes the lines of reefs, have of necessity been often only approximately delineated upon the plan.

History of the (Coolgardie) Goldfield.*

Although H. M. Lefroy, in 1863, C. C. Hunt, in 1864, J. Forrest, in 1871, E. Giles, in 1875, and D. Lindsay, in 1891, passed over various portions of what now forms the Coolgardie Goldfield, it was not till late in 1892 that gold was discovered within that area.

The real history of the Goldfield commences on the 18th of September, 1892, when Arthur Bayley first reported, at Southern Cross, the discovery of gold by John Ford and himself near the Coolgardie Water Hole. In 1891-2 several prospecting parties went East from Southern Cross to examine the quartz outcrops near the Hampton Plains, discovered by C. C. Hunt in 1864.

About the months of May or June, 1892, Arthur Bayley and John Ford, after fitting themselves out with two horses and provisions for a lengthy prospecting tour, left Southern Cross and travelled Eastward towards the Hampton Plains. They followed C. C. Hunt's old track, and, after crossing much monotonous sandy country, at length arrived at the Gnarlbine Rock, where they found fresh water and food for their horses. Here the party camped for two days to enable their horses to recruit. Setting out in a North-Easterly direction, they came to a native well, known to the aboriginals as Coolgardie. Grass was abundant, and allowing their horses to feed, they prospected in the vicinity of the well. This well, at which they camped, has since been replaced by a tank sunk by the Goldfields Water Supply Department, on the Government Reserve, to the South-East of the Coolgardie Railway Station.

* The following account of the History of the Coolgardie Goldfield is taken from the History of Western Australia by W. B. Kimberly.

Starting from this camp Ford was the first to discover gold, and picked up a piece weighing half an ounce which was lying on the surface. In a few weeks 200 ounces more were picked up or "specked" in this locality, which was afterwards to be known as "Fly Flat." Returning to Southern Cross for rations, they kept their secret and hastened back as soon as possible to the scene of their original discovery.

One Sunday afternoon, towards the end of August, 1892, Bayley broke the cap of one of the many quartz outcrops occurring in the vicinity of the camp, and thus proved the auriferous character of the afterwards celebrated Bayley's Reward Reef. The same day they had dollied out 500 ounces of gold by means of a tomahawk, the reef being phenomenally rich. Shortly afterwards Bayley returned to Southern Cross and reported his discovery, on the 18th of September, 1892, to the Warden and Registrar, Messrs. Finnerty and Compton. He applied for, and obtained the Reward Claim, known as Bayley's Reward G.M.L. 133.

Mr. Finnerty then returned with Bayley to obtain an idea as to the importance of the discovery, and with them went nearly the whole male population of Southern Cross. By the 8th of the following month, October, there were 150 men on the field, and before the 25th of the same month 3,000 ounces had been collected from the alluvial workings, which proved to be very rich. At the end of October, 1892, there were 400 men assembled on the field, and about this time the great scarcity of water began to be felt. Food, too, rose to a fabulous price, and the cost of water was several shillings per gallon. In consequence, towards the end of 1892, Coolgardie was nearly deserted.

About March of 1893, however, rain fell, and fairly good supplies of water were to be obtained, in consequence of which a greater influx of prospectors took place, so that by June, 1893, 1,492 persons were present on the field. From June, 1893, continual "rushes" to various scenes of discovery took place. The first of these was caused by a prospector, named Frost, finding gold at the "90-Mile," to the North of the present Coolgardie Townsite. On Saturday, 17th June, 1893, "Pat" Hannan and "Tom" Flannagan found rich alluvial ground at a distance of 24 miles to the East. This discovery was accidentally made by these prospectors while travelling to the Mount Youle rush. The following Sunday morning Coolgardie was all astir, and in the evening the place was almost abandoned, the men flocking to the rush on camels, bicycles, horses, and many on foot. For a short time the returns from "Hannan's Patch," as it is locally named, were re-

markable, but the richer reefs and ore deposits, which are now so successfully worked, were not discovered till some considerable time afterwards. The next "rush" was to the 45-Mile, where Messrs. Cashman and Lee reported gold. Of all the "rushes" from Coolgardie the most disastrous was the one to Siberia. Messrs. Frost and Bonner brought in news of their having discovered rich specimens 75 miles North-North-West from Coolgardie. The alluvial at "Hannan's" and "Fly Flat" had by this time been mostly worked out, and a great crowd started, with the true gold fever, on one of the worst watered tracks on the field, leaving Coolgardie and Hannan's almost deserted.

In a few days the want of water began to be very seriously felt. Mr. Renou started out on their tracks with two teams loaded with water, and leaving one tank at the 25-Mile, the other was taken on to the scene of the rush, while men on camels, provided with water, scoured the country in search of those who had separated from the main body. In spite of all these efforts, however, several deaths occurred, and had it not been for the prompt action on the part of Mr. Renou, in praise of which too much cannot be said, death must have overtaken a much greater number. Up to 1st July, 1894, the Eastern Railway extended only as far as Northam, but after that date railway communication was opened up as far as Southern Cross. In March, 1894, the Kurnalpi rush took place, and in May, 1894, that to the I.O.U. (Bulong). Both of these places lay to the East of Hannan's, and for a short time yielded a very large amount of precious metal. Shortly after this a series of rushes took place to White Feather (Kanowna), Broad Arrow (Kurawa), and Black Flag to the North-East, Wealth of Nations to the North-West, and Londonderry to the South of Coolgardie.

The Londonderry "find," which was discovered by a party of prospectors, Messrs. Carter, Dawson, Mills, Gardner, Elliot, and Huxley, proved to be enormously rich, 4,000 to 5,000 ounces of gold being dollied out of the quartz in a few days. Big Ben, a piece of quartz and gold broken from the outcrop, weighed 240lbs. (a.d.p.) and was valued at £3,500. Four thousand two hundred and eighty ounces were taken from this mine to Coolgardie on June 23rd, 1894. The property was shortly afterwards sold for £180,000 to Lord Fingall, who floated it into a company of 700,000 £1 shares. With such a handicap this mine soon fell into disfavour, especially when the "Golden Hole" was found to be of comparatively small extent. About July, 1894, Mr. J. G. Dunn discovered a very rich reef 28 miles West of North from Coolgardie.

This was afterwards known as the "Wealth of Nations," and proved to be almost as rich as the Londonderry find. In a short time Dunn dollied out £22,000 worth of gold, and afterwards sold the mine for £147,000.

In September, 1894, Messrs. R. Menzie and J. E. McDonald discovered gold to the North of Coolgardie, at a place now known as Menzies, and pegged out the Lady Shenton and Florence leases. No general "rush," however, set in to this place.

The Coolgardie Goldfield, as at present constituted, was officially declared on April 5th, 1894, and Mr. J. M. Finnerty was appointed as Warden, a Local Court being established on the 13th of the same month. Towards the middle of the year 1894, the population had increased to 3,000 or 4,000, so that if only for sanitary reasons it became necessary to proclaim Coolgardie as a municipality. This took place on the 4th July, 1894. The history of Coolgardie for the year 1895 is marked principally by the numerous flotations of properties and influx of English and Colonial capital. During this year no less than 39 local companies were registered, and power of attorney granted to 194. Prospectors received from £50 to £15,000 for their claims, which were then floated into companies with capitals ranging from £25,000 upwards, the most of which was in many cases swallowed up in expenditure, which left little for the development of the property. The total amount of capital invested is estimated to have reached the enormous sum of £50,000,000.

Towards the end of December, 1895, there were 6,000 people in Coolgardie, and 3,000 at Kalgoorlie, as Hannan's had come to be called. This increase in population in so short a time is probably partly accounted for by the increase in fresh water production by means of condensers. An abundance of salt water was always procurable on the field on sinking to a depth of usually about 100 to 200 feet, and this was then condensed by various methods hereafter described.

The year 1896 witnessed the rise of a land boom and the partial collapse of the mining boom. A fair idea of the prices paid for land can be formed when it is remembered that the Government realised £41,235 from sale of land in Kalgoorlie for the month of November alone. The influx of population from the Eastern Colonies was enormous during this year, the total reaching to 55,215, while the departures numbered only 19,266. It will not be an exaggeration to say that most of these new comers turned their footsteps Eastward.

On the 23rd of March, 1896, the railway from Southern Cross to Coolgardie was opened, and offered fresh facilities to intending prospectors, as it reduced both travelling expenses and the prices of food.

Since 1896 all the Eastern Goldfields; as well as Coolgardie, have suffered considerably from the reaction which set in after the great mining boom in 1895-6. This reaction is being less keenly felt now, and its ultimate result will be to promote more legitimate mining than was the case in the early history of the field. That the Coolgardie Goldfield is increasing its output of gold can be seen by the returns accompanying this report, and though the boom days are over there should still continue to be a steady increase in this output in the near future. Similar rich patches to those discovered at Londonderry, Bayley's, and Wealth of Nations may possibly be found from time to time, but on this point there can be no certainty, and it is on the development of the large low grade ore deposits that the future prosperity of the field must depend. Up to the present the working expenses have necessarily been too heavy for many of these ore deposits to be treated profitably. Strenuous efforts are however now being made by the Government to supply the field with fresh water from the Darling Ranges. This scheme, if successfully carried out, will reduce the expenses of ore treatment considerably, as it is estimated that it will be possible to supply fresh water to the mines at 3s. 6d. per 1,000 gallons, while the cost of salt water at the present ranges from 5s. to 10s. per thousand, and this supply is not regular. A copious supply of fresh water will also make living much less expensive, and so induce workmen to settle on the fields, instead of leading a nomadic life as at present. Taking into consideration the statistics of gold production, the development of mines, etc., there seems every probability of there being a lasting and prosperous future for the Coolgardie Goldfield.

Previous Observations on the Geology of Coolgardie.

In his Mining Handbook, Mr. H. P. Woodward, late Government Geologist, refers the rocks forming the greater portion of Western Australia to the Archæan age. According to his account, these Archæan rocks are usually crystalline, and are found outcropping throughout the Colony, and overlain only in isolated places by more modern formations; these latter are rarely of any great thickness. The Archæan rocks he divides into "three

" sections, the granites, the gneisses, and the schists, which, as a " rule, run in parallel belts North and South, with a slight trend to " the North-West. These belts are six in number. The first extends " from the Murchison River to the South Coast, and is only exposed " at Northampton, the Irwin River, and between Capes Naturaliste " and Leeuwin. The rocks in this belt consist of clay slates, " quartzites, and schists, and are characterised by the plentiful " occurrence of copper, lead, zinc, iron pyrites, and ferruginous " graphite. Parallel to this the second belt extends North and " South from the South Coast to the Murchison River, and forms " the bold escarpment known as the Darling Range. After passing " the Murchison River this belt turns to the North-East for about " 200 miles, and finally disappears beneath the magnesian lime- " stones to the Northward."

" In this belt the rocks are mostly hard and crystalline, con- " sisting principally of gneiss and schist, with dykes of diorite, " granite, and felstone, and veins of quartz. The minerals of com- " mercial value occurring in this belt are tin (at Greenbushes), iron, " and manganese, mica, and asbestos. Near Bridgetown a large " deposit of graphite has lately (1896) been opened up."

" The third, or great granite belt, lies 100 miles East from the " West Coast. It extends from the South Coast to the Murchison " River."

" The fourth, or first auriferous belt, is situated immediately to " the Eastward of the granite belt, and is some 20 miles in width."

" Starting from the South coast, at the Phillips River, it " extends Northwards in a narrow belt by the Ravensthorpe River, " Parker's Range, Southern Cross, Golden Valley, Mount Jackson, " Mount Kenneth, Mount Magnet, Austin's Lake, to Cue, and then " turns to the North-East to Nannine, after which it skirts more to " the North, round the bends of the Murchison and Ashburton " Rivers, and finally disappears beneath Paleozoic rocks, after " passing down the Ashburton Valley to its junction with the " Henry. The rocks of this belt consist of hornblende, mica, and " talc schists."

" The fifth, or second granite belt, is about the same width and " similar in every way to the first-mentioned. It extends from the " South coast, following the first auriferous belt North, and, like it, " dips under the Paleozoic tableland of the Fortescue. A small " portion of it appears on the Northern side of the Yule River, near Pilbarra."

"The sixth, or second auriferous belt, lies next, and at present "its width is unknown. It extends from Dundas Hills through "Widgemoultha, Coolgardie, Three Pinnacles, Ullaring, and Lake "Carey, following about the same lines as the other belts, and "turning with them to the North-West through Nullagine, Marble "Bar, Pilbarra, Egina, and Mallina, upon the North-West coast. "The rocks of this belt are, generally speaking, very similar to the "first auriferous belt—*i.e.*, they consist of hornblende, mica, and "talc schists.*"

"The ages of the other rocks, which are chiefly sedimentary, "range from Cambrian to Recent.†"

Baron Sloet Van Oldruitenborgh, in dealing with the geological history of the Western portion of Australia, considers that "it has "been dry land ever since the end of the Pre-Cambrian era, and "constitutes a vast tableland, which has formerly been continuous "with the old Austral-Indo-African continent (the Lemuria of "zoologists). The metamorphic schists composes this plateau, "and more particularly their upper layers, are interbedded with "numerous and frequently powerful overflows of diorite, diabase, "etc., which are probably of submarine origin, which overflows, "and seem to have been the precursors of the tectonical uplift, "whence arose the Austral Continent of primitive ages. Very "likely, near the end of the Permo-Carboniferous era, the partial "sinking of this Austral Continent, the successive depressions of "which have generated the (actual) Indian Ocean, must have "provoked in an Eastward direction a most intense compression of "all the strata that then remained of the West Australian portion "of the same continent."

"This East-North-East thrust has generated along the Western "shore, for a length of about 800 miles, the upheaval of a doubly "folded chain North-North-West perpendicular to the direction of "orogenical pressure."

"The roots of this Lemurian chain, traceable by outcrops of "granite and gneiss for some 800 miles, alone remain, and run "North-North-West in two parallel streaks, each from 60 to 100 "miles wide." ‡

Mr. S. Göczel, late Field Geologist, in writing on "The "Interior Gold Region of Western Australia" refers to its

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* Mining Handbook to the Colony of Western Australia, by Harry P. Woodward, F.G.S., F.R.G.S., etc., Government Geologist. Perth: By Authority, 1895, pp. 37 and 38.

† For a complete list of these rocks *vide* Handbook to the Colony, page 29.

‡ Technical observations upon the Coolgardie Goldfield by Baron Van Oldruitenborgh. Translated from the French for *Mining Journal*, London.

geological history in the following terms:—"The geological "monuments in the gold regions are bare of paleontological "remains, but none the less, taken in conjunction with features of "adjoining areas, they open a retrospective view into the early "geological history of that portion of the Colony."

Mr. Göczel then traces the history of the Colony, through the Paleozoic age, when "the Colony was represented by a volcanic "archipelago round which the Western part of Australia was "gradually built, and the gold region joined by secular upheaval."

"To the beginning of the Mesozoic age, when a more general "upheaval was completed, and volcanism in this portion of the "globe apparently lost its intensity and manifested itself chiefly in "seismal and hydrothermal activity."

"It was during later Paleozoic time that the writer considers "the bulk of the primary gold deposits were formed, and were due "to a hydrothermal gold emanation."

"In conclusion he inclines to the belief that the elevation of "the country above the sea and the later cessation of volcanism and "volcanic after action have inaugurated a new era, during which "great depressions occupied by inland lakes and estuaries were "successively filled in with rock material derived from the adjacent "high country." *

In a subsequent description of the Coolgardie field, Mr. Göczel states that it is situated at "the contact zone between gneissic "granite (which is partly overlaid by contact conglomerates) from "the West and diorite and diorite schists from the East, and encloses "a number of fissure lodes, most of which have a Northerly course. "The main fissures extend for miles, and contain predominantly "eruptive rock material; whereas ferruginous quartz with a higher "or lower gold yield is only of secondary occurrence within them."

The dykes he considers to consist "usually of diorites, diorite "porphyries, and porphyrites." †

Dr. Charles Chewings states in his pamphlet on the Coolgardie Goldfields that "the prevailing metamorphic rocks of the goldfield "are schists and slates." ‡

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* *Ad Interim* Report on the Department of Mines for half-year ending 30th June, 1894, Appendix 4. Perth: By Authority, p. 19.

† Report of the Department of Mines for the year 1895. Perth: By Authority, p. 24.

‡ Geological Notes on the Coolgardie Goldfields by Dr. Charles Chewings, Ph.D., F.G.S. A paper read before the Royal Colonial Institute, March 17th, 1896.

"Chemically these range from the most acid to the most basic, "petrologically from amphibole to quartz schist. The geological age "is probably not younger than Cambrian. Interbedded in these "schists are limestones. Vast beds of conglomerates are also found "interbedded with the schists and slates. One of these beds is to be "seen some eight miles West of Hannan's, and another at the White "Feather (Kanowna)." *

In reference to the eruptive rocks, Dr. Chewings maintains "that the Coolgardie Goldfield is the remnant of a large mountain "chain which has been planed down to its roots by denuding "agencies. This chain marks a line of weakness in the earth's "crust, through which poured the materials which formed the "chain, while vast quantities remained beneath, and have been "exposed to the present surface through the wearing away of the "upper portions."

In dealing with the portion of the Coolgardie field in the immediate vicinity of the Coolgardie Townsite, the author considers that this portion lies along "the contact zone between granite on "the West and amphibole schists and diorite on the East. Along "this contact line remarkable rich discoveries were made such as at "Bayley's and the Londonderry. Pegmatite dykes are commonly "found in the neighbourhood of such, notably at Londonderry." † As the gold in these two celebrated mines occurred in patches, the author considers that "the recurrence of similar patches is "likely." Dr. Chewings then refers to the occurrence of the auriferous granite porphyry dykes worked in the vicinity of and at Tindall's gold mine, and concludes by stating that though "the ore "in these dykes is not of high grade, there is any quantity of it."

With reference to the question of the geological age of Western Australia, the foregoing extracts have been taken from the writings of the geologists who have dealt with this subject, and have been placed before the public in this pamphlet in order that they may be known and compared. It might be added, however, that—

1. Accurate geological information about many—in fact, most—parts of the Colony, is at present unprocurable.
2. A great majority of the rocks are destitute of fossils.
3. The surface in many places is completely hidden from view by superficial deposits of a very recent age.

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* Report on so called deep leads at Kanowna by T. Blatchford; Annual Progress Report of the Geological Survey for the year 1897. Perth: By Authority, 1898.

† Geological Notes on the Coolgardie Goldfields by Dr. Charles Chewings, Ph.D., F.G.S. Read before the Royal Colonial Institute, March 17th, 1896.

4. Much of the Colony remains still unexplored.

5. The series to which a correct geological age can be attributed are usually disconnected.

Taking a general view of these obstacles, it will be seen at once that an accurate determination of the geological age of much of the Colony is an impossibility in the present condition of our knowledge.

The Geology of the Field.

The following is a concise description, based on personal observations, of the geological features, etc., of that part of the Coolgardie Goldfield embraced within the boundaries of the accompanying map :—

Topography.

Taking the Townsite of Coolgardie as a starting point, the country has a gradual and even slope for a considerable distance towards the West, the watershed running nearly due North and South.

The Eastern slope has a greater incline than the Western, and is broken by ridges of diorite which attain a height of from 100 to 300 feet above the level of the surrounding country. The direction of these ridges is irregular, though in the South the inclination is to a North and South course, while in the North the direction is more or less East and West. The country between these ridges consists of extensive flats covered with recent superficial deposits of a red colour, resulting from the decomposition of the ironstone gravels and the diorites and associated hornblende rocks.

General Geological Features.

The general geological features of the field are as follows :— Underlying the red alluvium on the Western slope lies a belt of intrusive granite running North 20° West throughout the length of the field, the Eastern boundary coinciding very closely with the watershed above described. Lying to the East of this belt, and dipping at angles varying from 30° to 60° to the East, and having an average strike corresponding to that of the granite, lies a belt of much altered and probably very ancient hornblende and talcose schists, through which have intruded diorites and acid eruptive rocks.

These, as a rule, follow the strike of the schists, though cases occur in which they cross the strata at all angles.

Closely associated with, and often inseparable from these diorite dykes, are amphibole rocks, which at the surface weather into the form of schists, and are often mistaken for such. As far as can be seen, however, these amphibolites pass into diorites at a depth, and, as at present it is not possible to follow this gradual alteration through all its stages, it will be interesting to trace the change when the mines are further developed. There is sufficient evidence, however, to show that the diorites are entirely distinct from those lying adjacent to the granite, as they vary greatly both in texture and chemical composition.

The acid eruptive rocks which occur in many places on the field as narrow dykes usually trend towards the granite, and in some cases the gradual change, from coarse granite to what appears to be a quartzite, can be traced through every stage. Associated with these dykes are belts of dark compact rock, closely resembling slate, both in texture and cleavage, and often containing abundance of iron and arsenical pyrites. On analysis this has been proved to carry as much as 8dwts. of gold per ton, the gold not being in a free state, but contained in the pyrites. Since these belts of slate-rock are usually found associated with the felsite dykes, and often lie on each side of the latter with a similar strike and dip, it seems more than probable that they are simply much-altered schists or hornblende rocks.

Overlying the granite are the remains of what was once an extensive ironstone gravel deposit. This deposit, which apparently extends over a considerable area of Western Australia, has been so subjected to denuding agencies in this district that, except where it has attained considerable thickness by filling in the eroded surface of the granite, it has been entirely removed.

Between the granite and these above-mentioned ironstone gravel beds can be seen in places a thin stratum of so-called "cement;" but, unlike similar deposits at the 25-Mile and Kanowna, this bed seems of limited extent, and, unfortunately, has so far been proved to be unpayable to treat for gold.

Alluvial Deposits.

The alluvium, which forms the flats and Western slopes of the field, varies in thickness from a few inches to some 400 feet. The following are the details of a section as seen in Rollo's Shaft

(Government Reserve No. 23), the position of which is shown on the map attached to this report:—

Description of Strata, etc.	Thickness of Strata.	Depth of Strata in feet and inches.
	ft. in.	ft. in.
Red alluvium	6 0	6 0
Blue clay	50 0	56 0
Yellow clay	30 0	86 0
Moist sand	1 0	87 0
Schist floaters, etc.	2 0	89 0
Blue clay	30 0	119 0
Blue clay, containing bands of lignite and shoots of pyrites	81 0	200 0
Yellow clay	55 0	255 0
Coarse diorite boulders	15 0	270 0
Mixed schist and diorite boulders	40 0	310 0
Dark wash	48 0	358 0
Blue clay and diorite boulders	22 0	380 0
Carbonaceous shale	8 0	388 0
Diorite and quartz wash	10 0	398 0
Black sand	1 6	399 6
Bed rock, probably diorite	...	400 0

Section of Coolgardie Deep Alluvial Prospecting Company's Bore in the vicinity of Colreavy's Dam, Government Reserve No. 23.

No. 1.

Nature of Strata.	Thickness of Strata.	Depth from Surface.
	ft. in.	ft. in.
Alluvium	10 0	...
Greenish clay	87 0	10 0
Jet black clay	7 0	97 0
Green and blue clays (with ironstone pebbles, etc.)	85 0	104 0
Hard country rock (schist, etc.)	4 0	189 0
Total	193 0	

No. 2.

Nature of Strata.	Thickness of Strata.	Depth from Surface.
	ft. in.	ft. in.
Red Alluvium	11 0	...
Ironstone boulders	3 0	11 0
Blue clay	29 0	14 0
Hard blue clay...	3 0	43 0
Soft blue clay	0 6	46 0
Hard blue clay	...	46 6
Total	46 6	

On the surface it consists of loose sand or quartz fragments, and ferruginous matter, the former being the result of decomposition of the granites, cements, and quartz reefs, the latter that of the ironstone gravels and hornblende rocks. The quartz particles, which vary considerably in size, are usually of a fine texture, and more or less rounded, probably by the action of the wind; and it is somewhat remarkable to notice how great an amount of friction is caused by the constant movement of the sand from this agency alone, by observing the results on glassware lying exposed to the open, the surfaces of such being invariably scratched to such an extent as to have a frosted appearance.

Lower down in the deposit, however, larger pieces of quartz are met with, and these are usually sub-angular and have probably been exposed to the action of water as they are met with on the eroded surface of the granite in what appear to have been ancient water-courses. In no case have I detected free gold in these blocks, and on inquiring from the miners working in such deposits the verdict has always been that they are barren. The ferruginous material which tends so largely to the composition of the alluvium, consists of impure oxide of iron, and is of a fine texture on the surface, with large loose-rounded pebbles of ironstone occurring in patches.

In many instances free gold is showing, both on the exterior and on freshly broken surfaces. After passing through the loose upper portions of the deposit, the amount varying with the locality, and immediately overlying the granite, the deposit becomes more compact, and often necessitates the use of explosives before the ground can be worked. This greater hardness is due to the solution and subsequent deposition of the iron, which then acts as a powerful cementing agent.

Examined under a lens or microscope, the finer samples show the presence of minute quantities of garnets and zircons occurring in broken and partly worn fragments together with magnetic iron, commonly known as "black sand." This latter was found in some quantity at the bottom of Rollo's Shaft, at a vertical depth of 394 feet, but, a pumping plant being necessary to cope with the influx of water, prospecting of any definite nature at this level was unfortunately prevented.

On consideration of the source from which these alluvial deposits were derived, and from the evidence of a heavier rainfall than that of the present day, it seems probable that gold may be found in payable quantities at the base of this deposit. On the other hand,

several of the small flats have already been tested without success; so it still remains doubtful whether the gold has been sufficiently concentrated to render it payable for working by present methods, assuming the old water-courses are eventually discovered. As showing that such ancient water-courses exist in other portions of the Coolgardie Goldfield, reference may be made to the report of the Government Geologist, in which a description is given of a deposit filling in an old valley.*

This deposit has been utilised as the source of the water supplied to Coolgardie by the Hampton Plains Company, and has been pierced by a bore to a depth of 162 feet.

The following is a section of the beds pierced:—

Nature of Strata.	Thickness of Strata.	Depth from Surface.
	ft. in.	ft. in.
Clay (with ironstone gravel)	27 0	...
Fine sand	30 0	27 0
Coarse yellow (water-bearing sand)	43 0	57 0
Clay	4 0	110 0
Sand wash	11 0	104 0
Kaolin (?)	8 0	115 0
Bed rock (nature undetermined)...	39 0	123 0
Total	162 0	

A large quantity of gold, however, has been won from purely surface workings by a method commonly known as "dry-blowing." This process of recovering gold from loose dry auriferous wash is somewhat unique, and gives very fair results when used by experts. Though simple in principle, great care is required when the gold is at all fine, and beyond a certain stage the process is absolutely useless. Hence the "dry blown" heaps still retain a considerable amount of gold, assays averaging in many places at least 10dwts. per ton.

There are several ways in which dry-blowing is carried on, the most primitive being to drop the wash from one dish to another, allowing the wind to blow away the light and finer particles during their passage, while the gold and coarser refuse falls into the lower dish. The large pebbles are then removed by "picking" with the hands, and the process repeated till the wash is sufficiently concentrated either to "spec" or wash with water in the ordinary way. As this is a very slow and laborious process, it was soon replaced by a simple form of machine, locally called a "shaker." Of these

* Report of the Government Geologist in connection with the Water Supply of the Goldfields; page 4. Perth: By Authority, 1897.

there are many varieties, though in all the principle is very similar, and may be briefly described as follows:—

Slanting wooden frames covered on the bottom with gratings of different meshes and partitioned by wooden ripples are fixed on stands in such a way as to allow the worker to either "shake" or "oscillate" the wash when placed on the sieves. The finest particles are thus passed through the sieves, while the coarser grains, owing to the incline, gradually pass over the ripples and discharge at the lowest edge; the gold, for the most part, settles down behind the ripples. The concentrates are then taken out of the boxes and carefully treated by the first process.

As an improvement on this, a pair of wind bellows are sometimes added to blow away the finer particles, and thus help the sieves. In such machines the bellows and sieves are worked in conjunction by being coupled by belting to a fly-wheel turned by manual labour. The principle of this machine is identical with the latter, but, being more cumbersome and expensive, though more efficient, it has not replaced the simpler and home-made varieties.

A more detailed account of this mode of gold recovery is to be found in an article by Mr. T. A. Rickard. *

The geological age of these alluvial flats is somewhat a matter of conjecture, as they have, with two exceptions, proved to be unfossiliferous, and it is doubtful if one of these two exceptions can be accepted as a genuine discovery.

The one undoubted discovery of plant remains was made in Rollo's shaft, at a depth of 380 feet, in a bed of carbonaceous shale eight feet in thickness. These remains have, on examination, proved to belong to the Eucalypti, and the age of the deposit is placed as probably late Tertiary.

Besides the plant remains and impressions, fossil bones were also said to have been discovered; but, judging from the pieces shown as such, there seems to be considerable doubt whether these fragments were ever pieces of bones, and whether they are not some secondary mineral.

Attached to this report, on a previous page, is a section of the shaft, which both illustrates the depth at which the plant impressions were found and the difference between this and the other alluvial deposits in the vicinity.

* "The Alluvial Deposits of Western Australia," by T. A. Rickard, State Geologist, Denver, Colorado. Transactions of the American Institute of Mining Engineers, October, 1898.

The second report of a discovery of fossils originated in the supposed unearthing of a large fossil tooth on Fly Flat. Unfortunately the evidence in favour of this discovery being genuine is somewhat faulty, while that against such is very strong. Most probably in some unaccountable way the specimen had been carried and deposited there by man. Mr. R. Etheridge (Government Paleontologist of New South Wales), to whom a photograph of the specimen above-mentioned had been sent, states that it "is a molar of the Indian elehpant (*Elephas Indicus*), and could only have reached its resting place by accident."

Cement Deposits.

Underlying the conglomerate, and resting on the denuded surface of the granite, lies a thin bed of "cement" similar both in character and appearance to that found in the "25-Mile deposits," and which most likely is a portion of those beds, or, if separate, was at least contemporaneous in its formation with them. Similar deposits are also found at Kanowna. As these deposits at the 25-Mile and Kanowna were the source from which a considerable amount of gold was won, I purpose to insert here some notes made from the descriptions given by Mr. S. Göczel and Mr. H. Y. L. Brown, Government Geologist of South Australia, also a brief account I am able to give from personal observations.

Cement Deposits at the "25-Mile."

Location of the Deposit.

The 25-Mile Cement Leases lie at a distance of some six miles North-North-West of the 25-Mile, the latter place being situated at a distance of 20 miles North of Coolgardie, on the Coolgardie-Menzies route.

The exact position of the deposit may be ascertained from studying the position of the following leases, on which the greater part of the cement was found. *

Name of Lease.	No. of Lease.	Acreage.
Hilton ...	100s.	19
Ophelia	105s.	13
Patena ...	356s.	3
Himalaya	357s.	3
Windsor	358s.	3
Hilton North ...	361s.	3
Coogee ...	362s.	3
Rock of Ages ...	363s.	3
Battler ...	364s.	3
Ruby	365s.	3

* The situation of these leases can be ascertained by a reference to the latest issue of the 20 chain lithograph of Mining Leases of Kintore Group, Coolgardie Goldfield, Kunanalling District, issued by the Department of Mines, Perth.

General Description of the Deposits.

Writing on the Cement Deposits at the 25-Mile (Kunanalling) Mr. T. A. Rickard gives us the following description:—"Under a "thin covering of sand and dust there occurs a bed of kaolin "ranging from a couple of inches to a foot in thickness, and this "overlies from 15 inches to two feet of 'sand-rock,' which in turn "gives place to the gold-bearing cement, which has an average "thickness of $2\frac{1}{2}$ feet. The last lies directly upon an irregular "surface of decomposed granite. The several layers composing the "deposit are separated by seams of pipeclay, which, like the kaolin, "are simply the product of decomposition of the constituents of the "granite, particularly the felspar. The sand-rock may be described "as a coarse incompletely consolidated sandstone or grit, consisting mainly of iron-stained particles of quartz loosely cemented. "The cement has a bluish grey tinge, owing to the play of light on the "quartz fragments. This too is not quite compacted, since fractures "through the material do not break across the pebbles, which are "harder than the clay binding them together. In this respect the "cement differs, for example, from the South African 'Banket' to "which it has been compared."

"The binding material, the overlying layer of kaolin, and the "sand-rock capping the gold bearing stratum of cement all exhibit "very clearly their derivation from a decomposed granite similar "to that which encloses the reefs and forms the bed rock of the "alluvium itself." *

Mr. Göczel refers to this deposit in the following terms:— "Lithologically considered the rock of which these deposits consist "is sandstone with more or less frequent transits into conglomerates. "The auriferous sandstone banks overlay immediately the country "formation. The latter is gneissic granite rotted or decomposed "to a considerable depth." †

"The component elements in the auriferous deposits are:—

"1. Sharp-edged quartz grains derived from the decomposed "country formation."

"2. Quartz breccia, derived probably from secretion veins, "which are contained in the decomposed country "formation."

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* "The Alluvial Deposits of Western Australia" by Mr. T. A. Rickard, State Geologist Denver, Colorado. Transactions of the American Institute of Mining Engineers. Buffalo, October, 1898, page 35.

† On the Deposits of Auriferous Cements at the 25-Mile Workings. Report of the Department of Mines for the year 1895. Perth: By Authority, p. 26.

"3. And occasionally small, rounded, and smoothened "quartz pebbles."

"The matrix cementing these rock elements consists chiefly of "crypto-crystalline silica, which frequently becomes more or less "ferruginous, imparting to the rock variegated colouring."

"The gold occurs embedded in the matrix, and the gold "particles are frequently visible to the eye. . . . . . In some "of the more ferruginous portions, pseudomorphs of brown hæma- "tite after pyrites can be observed. In such portions some of "the gold was associated originally with pyrites and became "liberated during the decomposition of the latter. Considering the "above observations, it follows that the cementing matrix and the "gold contained in the same are a contemporaneous precipitate "from one and the same thermal solution."

The cement consists of sub-angular and rounded fragments of quartz varying in size from grains smaller than a pin's head to pieces over an inch in diameter. These grains are usually bound together by kaolin in varying proportions, the hardness of the rock varying with the amount of kaolin present.

Where the cementing material is more or less absent the grains are usually of a finer or more even texture, giving the rock the appearance of sandstone, whilst it becomes so soft as to crumble easily under the pressure of the fingers. As a general rule iron-stone gravel overlies the cement and fills in the potholes and gutters cut in the latter. In places, however, it is found inter-mixed, showing that though the cement is of greater age, its deposition, at least in some places, was not complete when the ironstone was in process of formation, and thereby demonstrating the similarity of age of these deposits. The maximum thickness of the cement is about 15ft., with a maximum width of 90 to 100ft. The cement follows a serpentinous course along the much eroded surface of the granite for a distance of some $1\frac{1}{2}$ miles, though there are frequent breaks undoubtedly due to subsequent erosion.

In section, the deposit shows distinct horizontal stratification, with dark bands occurring at intervals; evidence which, when coupled with the subangular nature of the quartz grains and pebbles, leaves no doubt as to the sedimentary origin of the deposit. Between the cement and ironstone gravel is sometimes seen a thin layer, having a maximum thickness of six inches, of nearly pure white kaolin, which points strongly to the origin of the deposit being of a lacustrine nature. The floor on which these

beds rest is decomposed biotite-granite, the results of erosion being strongly marked by an abundance of "pot holes" and deep gutters.

Age of the Deposit.

Judging from the lithological character of the deposit, and the recent plant impressions found in what may be considered almost contemporaneous deposits in the Coolgardie district, the age of these beds may be put down as late Tertiary or Pleistocene.

Mr. H. Y. L. Brown, Government Geologist of South Australia, considers these beds to be of a similar age to the Cretaceous or Tertiary Cements found in other parts of Australia.

Yield of Gold.

The quantity of gold derived from the 25-Mile Cement Deposit, so far as official returns show, is, up to the end of 1897, as follows:—

Date.	No. of Lease.	Name of Lease.	Ore Treated.	Yield of Gold therefrom.	Rate per ton.
			tons.	ozs.	ozs. dwt. grs.
1897	100s (1931)	Hilton	4,397	6,836	1 11 2
1897	105s (1945)	Ophelia	1,000	527	0 10 12
		Total ...	5,397	7,363	1 7 6

Occurrence of the Gold.

Though the ironstone gravels and kaolin do contain small quantities of gold, they have not been treated.

The payable gold is, without exception, found in the cementing material of the quartz particles, the quartz pebbles themselves being barren, which is a considerable detriment, as this barren matrix has, as in the "Banket" in South Africa, to be treated with the cementing material before the gold can be recovered from the latter. In rare cases, however, gold has been found in the pebbles themselves, which though not important commercially, afford evidence as to the probable origin. The richest portions of the deposit have been found where the coarser material was lying on the bottom, and especially where it had gathered on the lower side of some of the larger "pot holes" in the granite.

Probable Source of Gold.

As the deposit was worked from the centre towards the edges, it was found to become much poorer in gold, till at the extreme

edges it was almost barren, not assaying more than 2dwts. to the ton. This absence of gold was often indicated by the colouring material in the kaolin; the barren parts being recognisable by the presence of a dull grey colour.

There can be little doubt that the gold found throughout this deposit has been laid down by the mechanical action of water, and, judging from the nature of the associated material, this deposition took place in a small shallow lake, the gold and quartz being carried down mechanically by inflowing waters from leaders and quartz reefs, of which there are examples existing at the present day. Mr. H. Y. L. Brown considers these deposits to have been formed along the shore of a lake or inland sea by aqueous action, the gold being derived from the veins and reefs in the bedrock beneath, and that only in the vicinity of auriferous veins can such a formation be expected to prove gold bearing.

He also thinks "that a thicker deposit (in other words deeper "ground) may exist in the vicinity of the cement cappings, and "that probably heavier gold would be found in such, and that the "gold now scattered through the whole thickness of the deposit "would be concentrated in the lower portion, lying above the bed-"rock in more defined runs or 'leads.'" *

Method of Treatment and Mining.

Being a shallow deposit, and on the surface, mining is carried on without impediment on the "open cut" system, the ore being carried to the batteries in small iron trucks, run on a light horse tram line.

On the Hilton Gold Mining Lease, No. 100s, the battery used is of Thompson's patent, and is worthy of description. This battery differs from the ordinary stamp mill in the following way:— Instead of having four stamps on one shaft, the stamps are run in pairs on parallel shafts connected by spur gearing, and so forms a nest of four. The feed is central, so all the material fed into the battery must pass under the stamps before reaching the screens. The discharge is an "all round" one, and consequently more or less radial. There are two amalgamating tables, instead of the usual single table in such mills as Messrs. Fraser and Chalmers.

* "Auriferous Deposits of Western Australia," H. Y. L. Brown, Government Geologist, Adelaide: By Authority, 1896.

So-called Deep Lead at Kanowna.

Locality of the Deposit.

The position of the "lead" is about half a-mile North-West of the Kanowna Post Office, extending from M^r.L. 637 Westward past the Cemetery.

The topography of the field is of a simple character. A low chain of hills curving from the Golden Crown G.M.L. (No. 3188E) to the North, East, and West, with minor heights in the Warden's and Hospital Reserves, form the higher grounds from which the surface gradually slopes and spreads out into extensive flats several miles in length.

Since the Kanowna field was originally discovered, dry-blowers have, in places, profitably treated the surface of many of these flats. Work was carried to no greater depth than from two to three feet, and discontinued when what was considered to be "true bottom" had been reached. Recent operations have proved this "bottom" to be merely a thin bed of coarse detritus cemented together and forming a somewhat compact layer of only a few inches in thickness.

It was not till the commencement of the year 1897 that this was proved to be of sedimentary origin by Messrs. Sim and Greson, who, sinking on their property (G.M.L. 637x*) struck a true "gutter" containing rich prospects of gold at a depth of about four feet from the original surface.

Though of similar occurrence, these "leads" are distinct from the old "cement" workings on this field, the latter being situated some $1\frac{1}{2}$ miles to the East of the present workings on the Eastern slope.

In dealing with the "cement" at Kanowna, Mr. T. A. Rickards considers that the origin of these deposits is clearly shown by studying the accompanying rocks. The greenish clay underlying the deposit he considers to arise from the decomposition of the epidote in the diorite as the kaolin arose from the decomposed felspar of the granites at the "25-Mile" deposits. The ironstone overlying parts of the deposit he likewise considers to have originated from the decomposition of the diorite. "The "cement lies in a shallow depression, at the upper rim of which the "quartz reefs cross the country. Furthermore, these reefs traverse

* *Vide* Lithograph, Kanowna District, North-East Coolgardie Goldfield. Perth: By Authority, 1896.

"a low divide, which, in a rough way, separates the deposit from "another (the Fitzroy cement), which slopes in the opposite direc- "tion."

In conclusion, he considers these cement deposits to be "the "placers of a country destitute of running water," and in support of this statement shows that the component parts (1.) have suffered little from attrition, and so have not likely been transported by water. (2.) They are the decomposed products of the surrounding rocks. (3.) They are comparatively unclassified, which is in keeping with the evidence afforded by the material of which they are composed. (4.) "The gold particles, which have rendered the "cement worth mining, are found to be identical in fineness and "physical appearance with the gold of the neighbouring veins, and "their scarcely rounded edges invite the conclusion that the gold "also has not been borne far from the place of its origin."* (5.) Transportation of the material has been carried on by the united action of wind and flood waters.

Mr. H. Y. L. Brown, Government Geologist of South Australia, examined somewhat similar deposits at the 25-Mile (Coolgardie Goldfield) and the cement deposits at Kanowna, and refers to them in the following terms:—"A limestone and ironstone "cement is found to contain gold at Kalgoorlie and elsewhere. The "auriferous cement deposit at White Feather (Kanowna), and at "the Kintore and Ormuz mines (25-Mile) is essentially an alluvial "deposit, *i.e.*, it is the result of denudation and the re-deposition of "gold from auriferous veins. The bedrock is coated in most places "with travertine limestone, and magnesium limestone, arising from "the decomposition of the rocks. Considering the wide area covered "over by the plains it seems probable that deep leads may in the "course of time be discovered beneath them, the alluvial gold-bearing "cement mentioned above representing the shallow ground of such "leads." †

Description of the "Lead."

For a distance of some 50 yards the prospectors followed up their discovery in an "open cut," but the "over burden" becoming thicker and thicker at length necessitated sinking and driving, which is now the practice in all the workings. The deposit here, and for some distance to the West, consists almost entirely of iron-

* "The Alluvial Deposits of Western Australia," by T. W. Rickard, State Geologist, Denver, Colorado. Transactions of the American Institute of Mining Engineers, Buffalo, October, 1898.

† "Auriferous Deposits of Western Australia," by H. Y. L. Brown, Government Geologist, Adelaide: By Authority, 1896.

stone pebbles cemented together with oxide of iron or kaolin, the former closely resembling ironstone lode stuff. The dimensions of the "gutter" vary considerably, ranging from two feet in the "prospectors'," to about eight feet in width in Messrs. Graham and party's claim, and from two to four feet in thickness. Proceeding to the Westward the deposit changes both in character and dimensions. Instead of the ironstone predominating as at the head of the "lead," kaolin and rounded grains of quartz commence to replace it (the ironstone only occurring in patches), till at length a width of 30 feet is attained. The thickness of the deposit is five feet; the lower two feet is that from which payable gold is obtained.

The gold, instead of being free, is more or less associated with quartz, and more frequently found in the form of small slugs than at the head of the "lead," though throughout the whole deposit it bears strong evidence of being mechanically rounded during transportation to its present position. Shortly after this change occurs, the "lead" apparently divides into two branches; the one trending North-West, and commonly called the North Lead, has been followed for a considerable distance, probably a mile; the other trends South-West, and passes through the cemetery and to a considerable distance beyond; this is known as the Cemetery or South Lead.

Output of Gold.

The following are the gold statistics of Kanowna as received from the Statist of the Mines Department:—

Date.	Class of Ore Treated.	Yield of Gold.		
		Ore Treated.	Total Yield.	Rate per ton.
		tons cwt. qrs.	oz. dwt. gr.	oz. dwt. gr.
Previous to 1898	Quartz ...	27365 11 0	28243 15 11	1 0 15
1898	Quartz ...	24858 2 0	20892 0 0	0 16 19
Previous to 1898	Alluvial ...	...	10611 18 10	
1898	Alluvial ...	...	63548 0 10	
1898	Cement ...	45983 4 2	68183 10 22	1 9 16
Total output ...	Reefs & Alluvial	...	191478 15 8	
Total output ...	Alluvial only...	...	142343 9 18	

Geological Structure.

The geological structure of the field, studied with special reference to the auriferous alluvial deposits, is, in general terms, as follows:—

Large dykes, grading from a true granite to a felsite, have intruded, broken, and contorted the schists, and, resisting denudation more effectually than the latter, now form the higher ground of the field.

The breccia, visible in many parts of the field, is evidence of the violence of these intrusions, and on examination will be found to consist of schist and rounded or subangular masses of porphyry. As the junction lines of these prophyry dykes and schists run North 20 degrees West and South 20 degrees East across the lead, much confusion has arisen regarding when to cease sinking, and for this reason I make special reference to the fact that either decomposed porphyry or schist will be the true bottom, varying in accordance to the position on the field; and I would strongly advise prospectors who have not struck wash to try similar localities in the neighbourhood, and not waste valuable time and labour sinking where there is little or no hope of success.

Prospects of the Field.

Judging from the character and structure of the surrounding country, the probable source of the alluvial gold on the Fitzroy Lead may be taken to be quartz reefs and leaders which traverse the main ridges above described, and if such be the case, there seems to be every probability that other channels radiating from this watershed may have been enriched in a similar manner. In support of this theory it is noticeable that the workings known as the "cement workings" lie on the South-Eastern face of the same watershed, and exhibit evidence of being the result of decomposition of the same rocks as those whose detritus is found in parts of the workings forming the subject of this report.

If this be the case, it necessarily follows that boring is a comparatively useless task, as the deepest deposit of alluvium is not more than sixty feet, and the leads are so scattered and difficult of location that sinking and driving would be the safer, and probably the cheaper mode of prospecting. In conclusion, I might add that in the technical acceptance of the term I do not consider this or any other of the alluvial deposits on this field to be deep leads, but merely auriferous alluvial deposits of comparatively recent age—probably late Tertiary—above which later deposits of alluvium and coarse detritus have formed an "over burden" of considerable thickness.

Only one outcrop of cement is to be seen in the vicinity of Coolgardie, and this extends from the Bluff, past the Recreation

Ground to the Coolgardie Brewery. The maximum thickness of this deposit is 8 feet, but this is exceptional, the average not exceeding 3 feet. Unfortunately this bed has so far proved to be of limited extent and of low grade as a gold producer, the prospects being so poor as not to warrant further investigations.

Ironstone Gravel Beds.

Scattered over a belt of the field, running North and South through the centre, are patches of ironstone gravel, usually semi-detached and surrounded by the alluvial deposits, to which they have supplied most of the fine red coating above described.

The thickness of these deposits varies from a few inches to some 15 feet. This must have been very much greater, however, when the deposit was first laid down, for at the present day there is a difference of at least 80 feet between the lower and higher levels. In addition, the immense amount of detritus found in the alluvial points to the more extensive nature of these beds, which were undoubtedly the source from which this was taken.

The composition, too, has changed, the old ferruginous clays having been altered *in situ* by concretionary action into ironstone nodules, which at the surface finally changes into the hard ironstone pebbles so frequently met with in this and other fields in Western Australia. In places these hard ironstone pebbles have been re-cemented together, forming compact impure ironstone, which is usually found on the caps of the high grounds, and never of any great extent.

On analysis a sample of this ironstone from near the Retribution Gold Mining Lease 2483, yielded, at the hands of the Mineralogist to the Survey, the following composition :—

Fe_2O_3	35·25 per cent.
FeO	00·51 per cent.

being an equivalent to 25·07 per cent. of metallic iron.

Assays made of the ironstone gravels gave results varying from 3 to 5 dwts. up to 8 dwts. of gold per ton, but it is doubtful, whether when treated in large quantities, such results would be obtained.

Over that area embraced within the accompanying map the remains of this deposit are seen to lie within the contours 1380 and 1460, showing that the deposit has a somewhat uniform level. Whether such uniformity exists in other parts of the Colony is at present unknown, but there is little reason to doubt that such is the case on the tableland portion of the Colony. On the other

hand, minor deposits are found at lower levels, such as at Coates' Siding,* in the South Western portion of the Colony and elsewhere. The origin of these latter can often be accounted for by examining the accompanying rocks, for in many instances undoubted evidence exists to prove that they originate from the detritus of the latter. No such evidence is to be found however to explain the origin of the more extensive class of deposit. Covering as it does such an extensive area, and taking into account deposits, such as the desert sandstones,† which have a similar habit, there seems to be much likelihood of its being a marine deposit. The total absence of fossils however renders an absolute decision almost impossible.

An examination of some parts of the beds in question shows that the nodular appearance is due only to surface weathering, the rock being at a few inches from the surface, merely a ferruginous claystone. This gradual change is traceable in most instances. It is therefore probable that the composing materials are either volcanic dust or the denuded products of some more or less basic rock, which have been in either case deposited in water. The only known evidence of extensive volcanic action on the central tableland is the occurrence of so-called "obsidian bombs."‡ Mr. R. H. Walcott, F.G.S., has dealt with the probability of the bombs being of volcanic origin, and has shown that various authors on the subject cast considerable doubt as to their being such. There is, therefore, practically no direct evidence as to the origin of these beds at present. A certain limit, however, can be made to their geological age.

At Rollo's bore certain plant remains were found in alluvial beds partly composed of the detritus of the ironstone beds. These plant remains, as already stated in this report, were thought to be of late Tertiary age. The ironstone gravel beds are therefore of an earlier age than late Tertiary. Overlying the Collie Coal Measures, which are thought to be of Mesozoic age, the ironstone gravels are again found occurring to a considerable extent. From this evidence an age, therefore, of between Jurassic and Miocene or Pliocene can be attributed to these beds in question, of which the later age is more probable, judging from their lithological character.

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* Annual Progress of the Geological Survey for the year 1897. Perth: By Authority, 1898. Page 4.

† Report on the Murchison Goldfields, by H. P. Woodward, F.G.S., F.R.G.S. Perth: By Authority, 1893.

‡ "The Occurrence of so-called Obsidian Bombs in Australia," by R. H. Walcott, F.G.S. Proceedings of the Royal Society of Victoria. Vol. XI., Part I., Art. III. Melbourne, 1898.

Granite.

Beneath the alluvium of the Western slope, and sending out offshoots in the form of narrow dykes which break through the diorites and schists of the Eastern side, lies an extensive and intrusive granite mass, approximately extending from the Coolgardie-Menzies and Coolgardie-Norseman telegraph lines to some three or four miles to the Westward. This mass has evidently broken in along the line of strike of the older schists and slates, as these are found on either side dipping away from the granite. They are also much contorted, twisted, sometimes broken, and in all cases much altered in their general characteristics. This alteration has probably been due either wholly or at least in part to the action of the intrusive granite. To the West of the slates, some three miles west of the Londonderry, occurs another granite mass, which differs considerably from the former, and whether the two are connected or not needs further investigation, great differences existing between the two, both in composition and general appearance.

Taking the Western examples first, they are found to consist entirely of large patches of quartz, mica, and felspar, sometimes with a weight of several tons, and quite separate from each other, or in the form of ordinary coarse granite in which the minerals have more or less blended together.

For some time the mica in this locality has been mined, a ready market being open for all the best quality that can be obtained. The greatest size in which it is found is 15 inches by 12 inches, but this is exceptional, the average not exceeding five inches to six inches. The mineral, when not less than about $\frac{1}{32}$ of an inch in thickness, gives a distinct sherry red colour when examined by transmitted light, but in sheets split finer than this it is difficult to detect colouration. Besides these large sheets the mica also occurs in long crystals which, when grouped together as they frequently are with the longer axes parallel, present a peculiar scale-like impression. The colour of such specimens varies from a pale pink to a pale green, or is quite colourless. The cleavage of all the varieties is very perfect. The felspar, which occurs like the mica in large bunches, is a potash one, and has good cleavages often developed so that it can be readily split into oblong blocks. The felspar is either colourless or possesses a pale sea-green hue. The quartz is almost colourless and glassy, and, as far as the workings show, occurs in less quantity than either of the other two associating minerals.

On the Gnarlbine Road, about two miles South-West of Coolgardie, on Reserve No. 3647, a bore was sunk 3,000 feet

in the hope of obtaining artesian water. Microscopic sections were cut from some of the core taken out at the 2,370 feet level, and on examination proved to be as follows:—The rock is a holocrystalline hornblende granite, somewhat clouded by the slight decomposition of the felspars, which with hornblende and quartz are well developed and fairly evenly distributed throughout the section. On close examination the felspars, with one exception, proved to belong to the monoclinic variety, distinctly showing single twinning in several crystals. The hornblende, which is of a dark green colour, occurs in lath-shaped crystals which are evenly distributed throughout the slide. It exhibits strong pleochroism, and in several instances shows cleavage planes crossing at an angle of 120 degrees. Occurring between the hornblende and felspar are patches of quartz, more or less granular, and usually showing stress figures. The freedom from inclusions is very marked. As accessory minerals muscovite-mica forms the most important, but is in small proportion compared with the hornblende. Small needles of apatite are found in places in the felspar crystals. Magnetic oxide of iron occurs in small grains throughout the whole rock.

A section cut from a piece of granite (2)* taken from the 496ft. level differs from the above in the following details:—The felspar and quartz in this section both show irregular forms, the former being considerably kaolinised, and in places showing a fair rectangular cleavage. Hornblende is scattered throughout the rock in irregular masses. Both the brown and green varieties are present. In one case only is a crystal of hornblende found showing idiomorphic contours. In this sample perfect cleavage is also present.

Iron is found in very small quantities in minute grains.

Apatite and muscovite are entirely absent.

Connected with the main mass of granite, and traceable from a true granite through every gradation to what appears to be a massive quartzite, occur acid eruptive dykes. These dykes, which are seldom more than 10 feet to 12 feet wide, cross the country in all directions, though they are often found following the strike of the schists. They are easily traced, both by their outcrop and their close association with thin bands; not more than nine feet wide, of a dark-coloured rock resembling true clay slate. These altered rocks invariably have the same strike and dip as the dyke with

* The figures in brackets refer to the Geological Collection number.

which they are connected, and seem to be, without any doubt, the product of contact metamorphism produced in the schist or diorite by the intrusion of the acid dykes.

On a microscopic examination the bands show an almost perfect slaty cleavage, texture, etc., with, in many specimens, a banded structure, in all probability due to infiltration of solutions and deposition of secondary minerals, especially magnesite and iron pyrites. In many specimens, too, are seen elaborate contortions of the bands and beautiful miniature examples of saddle reefs, in which the deposits are almost invariably magnesite. Examined under the microscope, the rock is found to exhibit a distinct banded or schistose appearance ; the minerals, principally felspars, with occasional crystals of quartz, hornblende, augite, and numerous grains of magnesite and crystals of pyrites, having arranged themselves in wavy bands, which are almost opaque owing to the oxidation of the iron either in the pyrites or more probably some ferro-magnesian constituent of the rock mass. Intermixed between these bands are abundant magnesite and probably calcite crystals, undoubtedly of secondary origin. These rocks having frequently been described as clay slates, thereby inferring a sedimentary origin, it might be useful to state the existing evidence to the contrary, and such is briefly as follows :—

1. They occur often in diorite, and intersect the dykes at all angles.
2. They are usually associated with acid eruptive dykes, having the same strike, dip, etc., and occurring in several cases on both sides of the latter.

In addition to these dark banded rocks, quartz reefs are often found in close association with the felsite dykes, in some cases apparently forming portions of the latter, and often following the same strike, etc. In such cases they are almost invariably barren, though branch reefs or cross leaders to these often yield good prospects of gold.

Microscopic sections of the dykes themselves show, in all its stages, the gradual change of granite from a holocrystalline rock to a pure quartz reef. A section of the granite has already been described, and except the diminution in size of the crystals, the character of the rock remains unchanged till a felsitic ground mass, with a few larger crystals of orthoclase scattered throughout makes an appearance, this ground mass becoming more and more acid till at length it becomes one of pure quartz.

Schists and Amphibole Rocks.

To the East of the granites, belts occur of what at the surface appear to be hornblende schists, having corresponding strikes to the intrusive diorites and granite.

On investigation of the nature of these rocks, it seems highly improbable that any are of sedimentary origin, as the successive changes from a schistose rock to either massive, hornblende, or diorite can be traced in several of the mines which have opened out below the 200ft. level.

For convenience of description they will be divided into two, and treated separately. The first and more extensive of these two divisions is found lying adjacent to the granite; this belt consists entirely of hornblendic and talcose rocks. In most instances where decomposition has not been extensive, they both possess a more or less perfect cleavage, but when much altered the cleavage vanishes, and the rock then becomes massive and more homogeneous.

Of the two varieties, the hornblende is the more important, as the talcose is very likely derived from the former, all the hornblende having a tendency to decompose into either serpentine or talc. Typical specimens of this rock, on examination, show the hornblende forming a kind of net work of long crystals in a ferro-magnesian ground mass. The crystals are usually partially decomposed, and sometimes only skeletons remain, the whole rock invariably having a greasy feeling when rubbed with the finger. The general strike varies from North 20° West, and South 20° East to North, 20° East and South 20° West, the angle of dip changing from 30° to 60° to the East, though in places the strata may be seen dipping to the West at similar angles, the change being due to subsequent intrusions of diorite dykes.

In several places these schists have been mined for building stone, blocks having been easily hewn either with saws or hatchets; but only in places where the schistose structure has been destroyed either by metamorphism induced by dykes, or where leaching has taken place to a greater extent. In such places the rock has a predominance of silicates of alumina, the magnesian minerals being present, but in a minority. Of the talcose variety little need be said, as they resemble the hornblende rocks in general features, differing only in composition, etc. They are usually of a greyish to yellow colour, very soft and greasy, and in many cases show distinct skeleton needles which have undoubtedly been hornblende

crystals similar to those in the hornblende variety. The cleavage is somewhat more perfect than the latter.

As before noticed, the next class, though resembling schists on the surface, change so quickly to massive hornblende that the almost inevitable conclusion is that the apparent schistose structure is simply due to surface weathering. Studied in sections the rock has no appearance whatever of a schistose habit, and the hornblende either arranges itself in a radiating form, or else becomes an irregular mass, with acicular crystals crossing each other at all angles. The foreign material found in this rock is, as a rule, in small quantities and consists of triclinic felspar, oxide of iron, magnesite, and in some cases calcite. The hornblende is of a dark green variety, and is usually in lath-shaped pieces, with a more or less radial structure. The felspar, though often much decomposed and cloudy, is seen to be of the oligoclase variety, and occurs in irregular patches throughout the rock, and mixed with the magnesite and calcite. In one instance free gold was found in a specimen taken from Mining Lease 113. Sections from a depth resemble diorite more closely still, as the hornblende occurs in more regularly shaped crystals, and does not have a radial structure. Taking all these points into consideration, it has been deemed advisable to map these rocks and diorites together, and distinguish them on the map by a single colour, as there seems to be little doubt that the amphibole rock is a diorite in which there is a preponderance of hornblende. There seems to be a great probability of the schists on the Western side of the field being the weathered remains of some ancient hornblende rock, but further investigation will be necessary to conclusively decide whether they are the same as those found in the deeper workings.

As regards the amphibolites, there is little doubt in my opinion that they are so closely associated with the diorites as to be inseparable from them.

Diorites and Andesites.

These occur in bosses and dykes, the latter originating from the main masses and found breaking through the schists, and in some cases are found in the granite. They are evidently not all of the same geological age, as instances occur in which they are found crossing one another, the andesites being undoubtedly the newer. On microscopic examination they are found to consist of hornblende and plagioclase felspar, varying in size from coarse grained varieties to a texture so fine that the individual minerals are not distin-

guishable even with a powerful lens. The coarser varieties are generally found as the centres of the main masses, the edges and dykes on the other hand consisting of the finer grained portions.

A large dyke having a distinctly porphyritic structure can be traced from Mineral Lease 1111 Southward through Gold Mining Leases 2051, 2937, 2576, and on past the Burbanks Birthday Gift to the West of the Londonderry. In this rock the felspars, which are both of the orthoclase and oligoclase varieties, have been so developed in the fine ground mass that they give the rock quite a mottled appearance, the crystals often attaining a size of at least a quarter of an inch in diameter.

This is probably the latest of the intermediate rock intrusions, as it is found breaking through both the diorites and schists. On microscopic examination these rocks exhibit the following characteristics:—

A section (43) taken from Gold Mining Lease 1699, Coolgardie. The section consists of crystals of dark green fibrous hornblende, showing marked pleochorism, quartz occurring in irregular granules, the base being a clear glassy felspar, probably orthoclase, showing few cleavages and little or no twinning. Small irregular patches of iron are scattered throughout the mass, and the whole rock, owing to a very regular arrangement of the hornblende crystals, has a distinctly schistose structure.

Another section (41) taken from Gold Mining Lease 651, Coolgardie. This section shows large irregular and a few idiomorphic dark-green crystals of hornblende. All show strong characteristic pleochorism, and in many instances perfect cleavages. Quartz is absent. The felspar shows neither cleavage nor twinning, and occurs in small irregular patches throughout the whole network of hornblende crystals; as in the previous specimens, grains of magnesite are abundant.

Water Supply.

In connection with the water supply of the Coolgardie Goldfield, the Government Geologist made a report * as to the possibilities of artesian water being found by diamond drill bores. He

* Reports by the Government Geologist in connection with the Water Supply of the Goldfields. Perth: By Authority, 1897.

also discussed the probable extent of the supplies gained from sinking in the decomposed granite and schist areas, and the accumulations arising from percolation into basins covered over by recent alluvial deposits, so no further reference need be made to the subject in this place.

The following are some statistics in connection with this subject, which have been collected since his visit to the fields, and which will doubtless act as confirmatory evidence to what he has already reported :—

Supply of Water from Wells sunk in decomposed Granite in Coolgardie Townsite.

No. of Well.	Depth in feet.	Supply per diem in gallons.
1	194	1,500
2	200	1,500
3	180	2,000
4	180	2,000
5	186	2,000
6	200	2,000
7	...	...
8	...	...
9	...	...
10	180	1,000
11	...	...
12	190	1,000
13	...	...
14	...	...
15	...	...
16	..	...
17	...	...
18	...	...
19	230	1,500
20	212	500
22	220	2,000
23	...	...
24	...	...
25	...	...
26	...	...
27	230	200
28	191	500
29	184	800
30	190	1,200
31	190	1,000
32	190	2,200
33	178	1,700
34	220	2,000
35	200	4,000
36	210	1,000
37	210	1,000
39	...	...
41	...	...

N.B.—The numbers refer to numbers on the accompanying map. Blanks are due to the abandoning of several of the wells, the supply being in excess of the demand.

Supply of Salt Water from Mines in Coolgardie Goldfield.

No. of Lease.	Name of Lease.	Output in Gallons per diem.
133	Bayley's Reward	10,000
400	... ...	Amount unknown, but in considerable quantity.
1966	... ...	50
1787, 1798	Derby Leases	2,000
2071	Queensland Coolgardie	1,000
232	... .	2,000
188A	Golden Bar	23,000
3319	Great Hanover	150,000
2725	Steadman's Choice	1,000
122	Cosgrove Bayley's Reward ...	10,000
1599	Rose Hill	15 to 20,000

It has been conclusively proved, especially in the wells, that the continual use of the water diminishes the output to the extent of at least one-half in a very short period. The annual rainfall of Coolgardie, as supplied from the records of the Observatory, Perth, is as follows:—

Year.	Points of Rainfall 100=1 inch.
1895	6·79
1896	8·51
1897	5·55

the average rainfall for the past three years being 6·95 inches. For the year 1893, April to December, the points registered were 9·41, and from May to December, 1894, the number of points were 4·79. As these two would include most of the rainfall for 1893 and 1894 they can be added to the others, and will then bring the total average for five years to 7·01 inches.

Comparing this average rainfall to the demand on the supply of water originating and depending on this source, the natural conclusion is that the demand would soon exceed the supply; on the other hand the demand for water for domestic purposes is constantly decreasing, owing to the extensive storage of rain water in galvanised iron tanks attached to the roof catchments. The supply for mining purposes is a somewhat more serious problem, for though, in some cases, there is sufficient, in the majority of cases, water will have to be, and is, brought from a distance, either from other mines or the Hampton Plains supply, the cost per 1,000 gallons ranging from 10s. downwards, according to the amount required. These supplies, too, are dependent on the rainfall, but what quantity is stored up in the deep alluvial basins from whence it is drawn can only be calculated by careful mapping out of the areas in which it is held. The probabilities of artesian water

supplies have been fully dealt with in the Government Geologist's report previously referred to, and, so far, the bores which have already been sunk have proved that artesian water does not exist.

The following are the details in connection with these diamond drill bores:—

Coolgardie Diamond Drill Bores.—Government Reserve No. 3448. Details supplied by Western Australian Government Water Supply Department.

Nature of strata.	Thickness of strata.		Depth from surface.	
	ft.	in.	ft.	in.
Alluvial	3	10		
Limestone conglomerate ...	12	0	3	10
Kaolinised granite	55	0	15	10
Soft white kaolin	32	6	70	10
Decomposed granite ...	36	8	103	4
Granite	2,383	10	140	0
Diorite	441	11	2,523	10
Granite	36	9	2,965	9
Total	3,002	6		

118ft. level salt water struck.

Coolgardie Diamond Drill Bores.—Government Reserve No. 3096. Details supplied by Western Australian Government Water Supply Department.

Nature of strata.	Thickness of strata.		Depth from surface.	
	ft.	in.	ft.	in.
Sand	7	0		
Cement	47	0	7	0
Kaolinised granite	9	0	54	0
Decomposed granite ...	102	0	63	0
Total	165	0		

Water level, 156 feet.

As can be expected, the water drawn from these underground sources is invariably more or less salt. The percentage of salts present varies from a slight brackishness, as in the case of some of the well water which is fit for stock, to an intense saltness, the amount of soluble saline matter sometimes being as high as 25oz. to the gallon. The greater part of the water being unfit for domestic use necessitates extensive condensing plants.

These condensers consist of two parts—the one in which the water is heated, the other in which the steam is converted through pipes, the exteriors of which are in direct contact with the air. These pipes are usually made of galvanised iron, though in two cases where the steam is under pressure strong iron pipes are in use. By these methods fairly pure water is obtained. The price per hundred gallons of condensed water ranges from 8s. to 10s. according to the amount consumed.

The following are some analyses supplied from official records to this office :—

Sample taken from Bore Shaft, Coolgardie, on 20th August, 1894.

Specific gravity (pure water, 1000)	1010
Solid matter (per gallon, 70,000 grs.)	861 grains
Solid matter containing chlorides of Sodium, Potassium and Magnesium	807 ,,
Sulphate of Sodium, Magnesium, and Calcium—Carbonate of Sodium	Trace
Iron	,,
(The liquid is colourless and odourless.)	
Taste	Salt *

Sample of water taken from the Coolgardie Town Well (in granite rock).

Water free from animal and vegetable contamination. Contains a small quantity of mineral salts, chiefly chloride and sulphate of lime, with traces of iron and magnesium. Water potable. †

As an example of the lake water, an analysis from a sample taken from Hannan's Lake yielded the following :—Soluble matter consisting of chloride of calcium, silicates, and chlorides of magnesium and sodium, and a considerable amount of alum, 22 ounces per gallon. *

Great inconvenience is experienced in conducting this latter, and similar water, through metallic pipes. The cause of this may arise from the erosion due to soluble salts, and probably from the presence of free acid. That free acid does occur in some of the water is proved by the condenser at Rollo's Bore, one mile from Coolgardie Townsite. ‡ Here the water was condensed from steam under a pressure of from 60 to 70lbs. per square inch. The arrangement of the condenser was such as to avoid any possibility of solid matter being carried over in the condensers. When using the condensed water for domestic purposes the following was

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* Analysis by B. H. Woodward, late Government Analyst.

† Signed by E. A. Mann, Government Analyst.

‡ The water condensed was from The Great Hanover Gold Mine, Limited, 331c.

noticed (1) that the water readily attacked metallic vessels, (2) that the water was "hard," (3) that it gave a strong reaction for sulphuric acid.

Water condensed under the pressure of the atmosphere only did not give these results, so that the natural conclusion was that acid requiring a higher temperature for evaporation is present in the water. The temperature at which sulphuric acid in water evaporates is 290° F., while the pressure of steam at 60 to 70lb. pressure requires a temperature of 293° to 303° F. Hydrochloric or nitric acid, if present, would evaporate at the lower temperature, and would not give a reaction similar to sulphuric acid.

Description of Reefs.

The Occurrence of Gold.

The gold won on this field has been derived from three sources, viz.:—Alluvial workings, lodes or formations, and quartz reefs. From the date of its discovery to the present day the Coolgardie Goldfield has been noted for its rich "alluvial finds," the first and richest of these being in the vicinity of Bayley's Reward Claim, and locally known as "Spud" and "Fly Flats." Besides the above named localities the dry-blower has prospected, often with success, most of the other flats on the eastern slopes, though only to a few feet from the surface, as in few cases do the alluvial deposits exceed a greater depth than ten feet. The form in which the gold has been thus found is variable, changing from coarse nuggets and slugs to so fine a quality that up to the present all efforts of the dry-blowers to recover it have been useless.

The methods used in the winning of this alluvial gold have been described on a previous page. Unfortunately, accurate information as to the size of the nuggets which were first found on the surface, is not procurable, because in most instances the discoverers of nuggets preferred secrecy, and when such information was printed in the local papers, this source was lost when the first news offices were destroyed by fire. From hearsay, it seems that a great number of pieces averaged from 10oz. to 60oz., some reaching a gross weight of at least 100oz.; but as there was a considerable amount of quartz in many of these the information is vague and unsatisfactory. In September, 1897, however, a nugget, weighing some 64oz., was found on Goldmining Lease 118, and was almost pure gold. Its depth from the surface was not more than six inches,

and it was found lying on the top of large angular diorite boulders covered up with fine red alluvium. The origin of this alluvial gold has undoubtedly been from several sources, inasmuch as the surrounding country is all more or less auriferous, and has suffered extensive denudation. But as the richest patches were found in the vicinity of lodes and quartz reefs containing gold, it is probable that the majority of at least the coarser gold was derived from the sheddings of these last-mentioned, while much of the finer must have undoubtedly come from the refuse of the old cement and iron-stone gravel deposits.

Lodes or · Formations.

These can be described as lenticular patches of ferruginous material, often only much altered schist, through which run numerous small quartz leaders forming "stockworks." As far as can be seen at present, such patches invariably pinch out when hard country is met with, though the quartz leaders sometimes unite into a quartz reef and continue, but become of low grade and charged with pyrites below water level. On the origin of these deposits Mr. S. Göczel has written in his report on the ore deposits of Coolgardie and Kalgoorlie*, and refers them to the "filling by "secretion derived from deep-seated solfatara solutions of the "fissures along the contact zone of gneissic granite and diorite and "dioritic schists."

The last dykes to force their way through the schists, diorites, etc., were those belonging to the acid eruptive series, and, in following the course of such one notices that the majority of these smaller "stockworks" are in close association with the acid dykes. Through their agency lines of weakness were formed, into which permeated solutions carrying gold, alkaline carbonates, etc., either from the surrounding rocks or in some cases partly from subterranean sources.

The boundaries of these lodes are very often absent, the only difference between the lode and country rock being that the former is auriferous, and sometimes, not always, crossed and recrossed by small quartz leaders.

When these quartz leaders are dark coloured, due to the presence of oxide of iron, they are usually more or less auriferous. Though much gold has been won from this source, these lodes

* Report of the Department of Mines for the year 1895, with Supplementary Notes on part of 1896. Perth: By Authority, 1896. Appendix 3. Ore Deposits of Coolgardie and Kalgoorlie.

when rich in gold are so small and irregular in habit that much of the profit is of necessity often wasted in prospecting and expensive treatment, and when they are of any extent are invariably found to be of low grade.

Quartz Reefs.

The quartz reefs occur principally in the schists, running in a general North and South direction, and usually with a dip of 60° to 80° to the East. There are two distinct varieties, one closely resembling the lode formations and occurring in large lenticular patches, often exposed at the surface as "quartz blows"; the other class belongs to the true fissure type. Of the first variety the reefs on Bayley's Reward Claim and the Big Blow Mining Lease, No. 35, are the best examples, while Sherlaw's Perseverance and Burbank's Birthday Gift Mining Lease, No. 3252, are typical examples of the second class. Whether those possessing a lenticular shape will be found occurring again at greater depths remains as yet unproven. There is one notable instance of this "remaking" both in a horizontal and vertical direction in Bayley's United Mine. Here the reefs are found to taper out horizontally, and eventually are lost, but on cross-cutting are found remaking, and sometimes overlapping, the new reef coming in as gradually as the old one disappeared.

There is also proof of the reefs in this locality behaving in a similar way vertically. At the deeper levels the quartz reefs usually carry arsenical and iron pyrites, and no doubt the oxidation of these minerals has been the chief source from which the free gold in the top levels has been derived. The mode of occurrence of the gold in the quartz is what is generally termed "patchy," and is found in shoots sometimes of great value, for example, that in Bayley's, where several thousand ounces of gold were found in a very small area.

Much speculation as to the origin of these patches has been brought forward, the usual theory being that of a secondary deposition from solfatara sources, but this seems improbable, as the gold is found surrounded by solid quartz.*

Minerals found associated with the Ore Bodies.

Several metallic minerals are found in the auriferous ore bodies above described, and are usually seen in close association with the gold therein. Of these minerals the most important are the

* Technical Observations upon the Coolgardie Goldfields by Baron Sloet Van Oldruitenborgh.

sulphides and arsenides of iron, and sulphides and carbonates of copper. As a source of gold, arsenical pyrites has, so far, proved to be the most productive, especially in Bayley's United Gold Mines (Gold Mining Leases 133, 139), where the pyrites carries large quantities of gold, both in the free and combined state.

In other mines such as the Flagstaff (Gold Mining Leases 1604, 1605), and Jubilee (Gold Mining Lease 3511), the arsenical pyrites is more or less mixed with sulphides of iron, and is of lower grade. Occurring in most of the lodes opened out below water level are large quantities of iron sulphides ; these assume two forms —ordinary iron pyrites and pyrrhotine * (magnetic pyrites). Both forms are of frequent occurrence throughout the field, but only in one instance have they been profitably treated, viz., at Sherlaw's Perseverance (Gold Mining Lease 3415).

In the mines in which the copper ores occur, little, if any, work has been done below the oxidised zone, in consequence of which the prevailing copper ores are the blue and green carbonates. These are found mixed up with the quartz, and are not rich enough to work as copper ore. Good samples of the mines in which such ore is found are the Black Prince (Gold Mining Lease 2208), the Lombard (Gold Mining Lease 1721), and the Sydenham (Gold Mining Lease 1711). At the surface, in these mines, small quantities of red oxide of copper (cuprite) are also found, but to an inappreciable extent. Native copper also exists in some of the reefs in the form of small grains of the unaltered metal, and, as such, seriously hampers amalgamation of gold. Such inconvenience is experienced in the Golden Bar (Gold Mining Lease 20) where native copper is found in considerable quantities.

Of the more rarely occurring metallic minerals, the most important are galena and molybdenite. This latter is sometimes mistaken for galena. The galena is found in the quartz in the form of small irregular cubes, and is a sure indicator of higher grade ore. Free gold is sometimes visible in the galena crystals, showing the intimate connection between the two. The most noteworthy example of galena in quartz is to be found in the Union Jack (Gold Mining Lease 1385). In one instance molybdenite was found occurring in amphibole rock in the Ensign (Gold Mining Lease 1953). The relation, if any, between this mineral and the ore bodies was not apparent.

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* Dana gives the composition of pyrrhotine as FeNS (N + 1), but usually as Fe_7S_8. *Vide* Dana's "System of Mineralogy."

Of the non-metallic minerals the most important are the carbonates of magnesium and calcium, and sulphates of calcium. As most of the rock-forming minerals near the surface have undergone extensive denudation and alteration, the products have been rendered more liable to the solvent powers of percolating waters. In consequence, secondary minerals such as calcite, dolomite, etc., are of very common occurrence. Of these the most important is the dolomite, which ranges from almost pure magnesite on the one hand, to calcite on the other. Filling in the crevices and cavities left by the removal of former minerals, these dolomites are found either in the crystalline or amorphous form; as the former they are often mistaken for felspars, as the latter for carbonate of lime only.

The white nodules which are so often seen on the surface are another form of magnesium mineral, and consist largely of hydrous silica and magnesium carbonate. In consequence, all attempts to burn such in hopes of obtaining a product for building purposes have proved futile.

Both magnesium and calcium carbonates are frequently found in the amphibole rocks, and take the place of the felspars. This replacement is sometimes due to decomposition of the felspars only, while in others the supply of mineral is drawn from aqueous solutions permeating the crevices of the rock.

Occurring in association with these carbonates, sulphate of lime is the most important mineral. In Sherlaw's Gold Mine (Gold Mining Lease 3415) an admixture of crystalline gypsum and calcite is seen filling what was once a cross fissure. The gypsum is found here in flat plates, while the calcite assumes a scalenohedral form, this shape arising from the peculiar arrangement of the small rhombohedrons.

The Mines.

During my work on the field I made notes, when possible, on the workings and underground features of the mines from a geological point of view only, and not with any intention of disseminating information as to the intrinsic value of the properties. The object of such observations is to give to the public a reliable statement as to the trend of the lodes, their dip, size, and other structural features, as well as the amount of development, and, when possible, the probable behaviour of the ore bodies.

Such public information cannot interfere with legitimate mining or the interests of individuals, and may prove of considerable utility to the investor and prospector. It will be seen, no doubt, that the names of many of the mines are omitted in the following descriptions, and such omissions will be found to be due to my inability to descend the mine, either on account of its being abandoned or under exemption during the time of my visit. As a whole, I received in the course of my work the most cordial assistance from numerous mine owners and others, and take this opportunity of expressing my gratitude therefor.

Balmoral Castle Gold Mining Lease 2754.

The reef on this property is a continuation of the Hurtle Grove reef. On this lease one shaft has been sunk to a vertical depth of 50 feet. Driving was then carried on to the East from the bottom level for 100 feet in order to try and intersect the Hurtle Grove reef, but without success. The country intersected in this drive consisted of highly kaolinised rock (decomposed schist) with narrow bands of probably altered dioritic rock. The strike of the country is North 20° East and dips to the East at an angle of 70°.

No crushings have been made of the reef opened out on this property.

Bayley's Consols Gold Mining Lease 22 (No. 2 South).

This lease is situated to the South-East of Bayley's United, and is on a branch of the same series of reefs as Cosgrove, Bayley's Reward, Golden Bar, etc. In occurrence, however, the quartz bodies differ from those found in the mines to the South, and closely resemble those opened out in Bayley's United. The workings are all connected to one main shaft, which has been sunk to a vertical depth of 220 feet. Prospecting was at first started in a whip shaft to the West of the main shaft, and in some unaccountable way the main shaft was sunk on the wrong side of the reef, which has a slightly Westerly, not an Easterly, underlie. Under the present management, however, the quartz bodies have been well opened up in three levels, which are connected to the main shaft by crosscuts about 92 to 97 feet in length.

In the 120 feet level the reef has been opened out to a distance of 110 feet South and 35 feet North of the crosscut, and is seen to have a thickness of four feet in the South face, while it tapers out in the Northern end. The strike of the reef is North 45° East, with a slight underlie to the West.

Two hundred feet level.—The drives at this level follow the reef 148 feet to the South and 39 feet to the North of the crosscut. It is doubtful, however, whether this is the same quartz body as in the top level, as the reef, though fully four feet in thickness on the floor, has almost pinched out in the roof of the drive. The character of the quartz is the same, however, being of the milky-white vitreous variety. This reef, however, extends to the bottom level, and strikes North 42° East, with an underlie of 75° to the West. Stoping is now being carried on to some extent between these two levels, the quartz body attaining a maximum size of some eight feet.

Though not conclusively proved, there seems to be little doubt, however, that these quartz bodies will prove of a similar character to those in Bayley's United (Gold Mining Lease 133). At a distance of 77 feet from the main shaft, in the crosscut at the 120 feet level, a branch, probably of the felsite dyke which has been described as occurring along this line, is seen in section, and has a thickness of some seven feet. This is probably a branch of the dyke met with in Bayley's United mine, and no doubt accounts for the faulting of one of the reefs in the latter.

The country rock is a coarse-grained hornblende rock, merging into more or less typical diorite at the greater depths.

At the 200 feet level the black bands charged with pyrites, which are so often found in association with the felsite dykes, are seen on the foot wall. The quality of the quartz is white and vitreous, and shows in the lower levels variable quantities of pyrites.

The total output of this mine, as taken from official records, is 3,977 tons crushed, with a yield of 2,387ozs. 18dwts. of gold, giving a rate of 12dwts. per ton. The value of the gold is £3 17s. 10½d. per ounce, giving a total value of £9,297 10s. 11d. to the gold won.

Bayley's United Gold Mining Leases 133, 139, 142, 547.

Three distinct parallel lines of reef occur on this property, and have been opened out from three main shafts known as the "Sylvester," "Price" and "No. 1 South"; of the three reefs the outcrop of one only is now visible at the surface, and stands out as the highest part of a small ridge to the North-West of the Price Shaft. The reef at the Sylvester Shaft also outcropped, but has since been stoped out to the surface from the 100 feet level.

The Sylvester Shaft.—The vertical depth of this shaft is 523 feet; levels at the 100 feet, 170 feet, 200 feet, 280 feet, 380 feet, and 480 feet have been opened out along the reefs and connected to the main shaft. The shaft is well equipped with hauling gear. Compressed air rock drills are used in place of ordinary hand drill labour.

One hundred feet level.—From this level to the 170 feet level the reef is practically vertical. From the main shaft it has been followed as far South as the Green Shaft, where it is faulted and thrown to the West a distance of nine feet, and then recontinues for a distance of 10 feet to the South, after which it tapers out. The average thickness of this reef is three feet, and it has been stoped out to the surface.

To the North of the Gordon Shaft, a lens-shaped reef was opened out to the 100 feet level by an underlay shaft. The reef was then found to discontinue, but has been all stoped out from the 100 feet level to the surface. It was at the cap of this reef that the celebrated "Bayley's Find" took place.

Number 2 (170 feet level).—The crosscut to the drives, from the main shaft, at this level, is 50 feet to the West. Where the crosscut joins the drive, the reef is eight feet in thickness. From here the reef extends for a distance of from 45 to 50 feet to the South, and then tapers out. Some 18 feet further South, however, the reef remakes and continues to the end of the Southern drive. A winze was put down on the reef to follow it to the No. 3 level, but at a short distance below the No. 2 level, it was found to taper out. In consequence it seems probable that this is a distinctly separate body of quartz from that opened out in the lower levels. The average thickness of the reef along this level is about four feet. The quartz is of a white vitreous nature.

Number 3 (220 feet level).—Here the reef is followed to the North for some 30 feet, and South for 100 feet, at which distances respectively it is seen to taper out.

The maximum thickness of the quartz in this level is about six feet, and occurs near the centre, gradually diminishing to the North and South.

Number 4 (280 feet level).—In the Southern drive the reef continues from the shaft for 40 feet, when it is suddenly cut off, and a hard fine-grained diorite forms a solid face. This is evidently a fault, though, as the workings have not been continued, further particulars are not obtainable at present. The reef is some six feet in thickness at the shaft, and four feet at the face.

In the Northern drive the reef tapers out at a distance of some 20 feet from the main shaft. The underlie of the reef at this level is 70° East for some 30 feet and then 45° to the East till it reaches the 380 feet level, when it assumes a fairly constant underlie of 70° East. Such is seen to be the case in a winze passing from No. 4 to No. 5. levels.

Number 5 (380 feet level).—A crosscut, 50 feet in length to the East, connects this level to the main shaft. Following along the drive to the North the reef is seen to continue for about 20 feet, when it tapers out and has not re-occurred in the drive, which has been continued for a distance of 180 feet. At the end of this drive a crosscut has been put in 60 feet to the East, following a band of softer country resembling a line of fault, but no reef was discovered. In the Southern drive the reef pinches out at 60 feet from the crosscut to the main shaft. This drive has also been continued for a distance of some 250 feet in hopes of the reef re-occurring, but without success. The strike of the reef in these drives is North 35° West, with an underlie to the East.

The " country rock" as seen throughout this mine is dioritic, varying from an amphibole to a very hard and close-grained diorite. Occurring along the walls, which are usually more or less serpentinous, due to the alteration of the magnesian salts in the hornblende, one sometimes finds rock more or less graphitic, the origin of which has not yet been accounted for.

Passing through the coarse hornblende rocks the mode of occurrence of the finer grained ones resembles that of intrusive dykes, except that there is no evidence of contact metamorphism visible. However there is no doubt as to there having been extensive faulting, and such I think will be found to have occurred before the formation of the reef, otherwise there would have been evidence of such in the reefs themselves. That the quartz has penetrated several distinctly different fissures in the country rock there is no doubt, neither is there any reason to suggest the possibility of the three series being at one time one continuous line. From the lowest level to the surface little or no water is met with in these workings.

Price Shaft.—This shaft is the most Northern of the three main shafts, and has been sunk to prospect the line of reef running parallel to but to the North of the reef prospected from the Sylvester shaft. At the date of my visit the vertical depth of the Price shaft was 270 feet. Levels had been opened out at the 40,

100, 170, and 250 feet. Of these the 40 feet level is not directly connected with the main shaft, but was connected to and worked from an old prospecting shaft situated to the North of the main shaft.

Number 1 (100 feet level).—On this level the reef is followed from some 60 feet South of the main shaft to the Cockshot shaft, when the reef ends. The thickness of the reef throughout this level is from nine to fourteen feet. Two winzes are being sunk on the reef to connect with the No. 2 level, and thus open out a large body of stone. A drive from No. 1 winze turns to the North-West, and then North to connect with the Everard shaft. In this drive a new reef comes in just North of the air shaft, and continues North to McCulloch's shaft; the reef is six feet in thickness in the centre, but tapers out at both ends. In the 40 feet level the same reef as is in the North of the 100 feet level is followed from the air shaft to the North past McCulloch's shaft. This reef outcrops at the surface. A winze put down at the 100 feet level proved that the reef tapers out vertically at the 120 feet level, and thus proved it to be distinct from the Southern quartz body, though in appearance there is great similarity, both reefs being of a white and vitreous nature.

No. 2 (170 feet level).—In the South drive the reef is found at a distance of 35 feet from the main shaft, and continues South to the Cockshot shaft, where it tapers and eventually discontinues. For the first 45 feet of the Northern end, the reef varies from four to 12 feet in thickness, but the Southern portion does not exceed five feet. Prospecting has not been carried on to the South of the Cockshot Shaft.

No. 3 (250 feet level).—At this level the reef, which strikes North 30° West and South 30° East, has been opened out some short distance to the South of the main shaft. Here the maximum thickness is 12 feet, but the reef pinches out in the North end, though it seems likely to continue some considerable distance to the South. The quartz is heavily charged with arsenical pyrites, which is considered a good indicator of gold. A very small quantity of the stone in these reefs has been treated, though the mine is well opened out, and large quantities of ore, when required, can be easily obtained. The quartz, as in the Sylvester Shaft, is vitreous and white, showing small quantities of arsenical and iron pyrites.

No. 1 South Shaft.—This shaft is situated near the battery, and has been sunk to prospect a third series of reef which runs

parallel and to the South-West of the other two reefs on this property.

The shaft is opened out at the 230, 170, 120, and 90 feet levels. Owing to the large influx of water (about 10,000 gallons per 24 hours) two of the levels were full of water. At the lowest, or 230 feet level, a considerable amount of driving had been carried on to the North and South of the main shaft. The reef at the shaft has a thickness of nine feet, and is four feet six inches across the Southern face of the drive, which is 50 feet from the main shaft. The strike of the reef is North 50° West. Following along to the North, the reef tapers out at a distance of from 60 to 70 feet North of the shaft. Here there is a discontinuation of the reef but for a short distance only, another reef coming in at a distance of nine feet to the West of the first one. This second reef continues for some 50 feet, and then discontinues, though the drive was carried on many feet to the North.

A crosscut to the East, however, of 20 feet revealed another reef, which in its turn pinched out after attaining a length of some 70 to 80 feet. The average thickness of this reef is five feet. All three have approximately the same strike, and are vertical.

The upper workings have opened out these reefs so that the whole are ready for stoping. These are the most perfect examples of the lenticular nature of the reefs to be found on the field, and as there is no clue to their relative positions, prospecting is rendered extremely difficult and expensive.

With the exception of a narrow felsite dyke found in the 90 feet level at a distance of 240 feet South of the main shaft, the country rock is similar to that in the other two workings, and consists of hornblende or amphibole rock and diorite. The excess of water in these workings is probably accountable for from their proximity to the felsitic dyke, which in all probability has disturbed the country, and opened out lines of passage for the water. The theory has been put forward that the reefs in this, and similar mines have been faulted and so are discontinuous. If such were the case it is highly improbable that the ends would taper so persistently; and though the termination of the reefs in two cases is abrupt, this will not account for the repeated occurrence of the other form. The occurrence of gold in this mine (Bayley's United) has been phenomenal for its richness, both in native gold and rich arsenical pyrites, containing at times free gold. Such has usually been found in patches or "chutes," the origin for which, in the "Interior Gold Region," has been accounted

for by Mr. S. Göczel in the following terms:—" During subsequent " movements in the earth's crust, already complete quartz lodes " were broken through, and sometimes dislocated by newly formed " fissures, and in some instances the original lode fissure was partly " reopened. Fractured portions of such broken reefs gave easy " access to circulating mineral solutions, and if those solutions were " derived from subterranean solfatara action, and were auriferous, " these conditions favoured the formation of rich gold shoots and " auriferous ore columns in otherwise poor or barren quartz " reefs."*

In the quartz reefs on the Coolgardie Goldfield there was one example only, to my knowledge, in which subsequent infiltration and deposition of mineral has taken place in a fault in the reef, viz., Sherlaw's Perseverance (Goldmining Leases 3415, 3416), and here the faulting was most marked. The great indicator of rich patches in the Bayley's United reefs is not the presence of faults but of arsenical pyrites, and, as is the general rule, this mineral is not uniformly distributed through the reef, and being of a highly auriferous nature, in this mine its presence in the lower levels would naturally point to the occurrence of free gold in the oxidised zone. Taking one other example of a phenomenally rich gold reef, I would quote the famous Londonderry mine. For a considerable time after the " Golden Hole " proved to be a failure as a gold producer, the mine was considered to be of low grade and unpayable, except where rich patches occurred. This was proved otherwise when systematic prospecting opened out the reef and revealed the true value of the mine.

At the 250 feet level the reef was proved in places to be some six to eight feet in thickness, but only the last few inches, on the hanging wall of the lode contained much gold, the remainder of the reef not averaging more than from two to five dwts. Such can scarcely be known as a " chute," as the richer portion is more or less continuous in habit.

In dealing with the amount of gold obtained from these three reefs, no record has been kept from which the individual outputs can be taken. Taken collectively, 18,670 tons of ore have been milled, and have yielded a return of 53,249ozs. of gold, or at the rate of 2ozs. 17dwts. per ton. The estimated value of the gold won is £207,327 7s. 2d., giving the gold an average value of £3 17s. 10d. per ounce.

* Report on the Department of Mines for the year 1894. Perth: By Authority, 1895, page 18.

Big Blow Gold Mining Lease 3,590.

The Big Blow Gold Mine, as its name would imply, is conspicuous on account of the outcrops of quartz, which rise to a considerable height above the surface of the ground.

Shafts have been sunk in four places to test the nature of these reefs, but to date the owners have been unfortunate in that the reefs have proved to be lenticular masses of quartz rather than continuous fissure veins.

No. 1 shaft, from which most of the stone has been taken for treatment, is situated between the two quartz outcrops, and has been carried down to a vertical depth of 150 feet, and levels opened out at the 35 feet, 85 feet, and 150 feet. In these workings, the larger quartz reef has proved to have a North and South strike, with an underlie to the East, while the smaller lode strikes to the East of North and underlies to the West. Taking the levels in order from the first, downwards, the following description will give an idea of the amount of underground work completed.

No. 1 (35 feet level).—The crosscut to this level from the shaft is eight feet in length. Drives have then been opened out along the reef to the North for 75 feet, and to the South for a distance of 35 feet. Along these drives the reef averages about seven feet in thickness. The quartz is white and glassy in appearance, and almost destitute of foreign minerals. Perhaps the most profitable part of the mine in this level is the stockwork through which the drives pass. The dimensions of this ore body exceed 20 feet in thickness in places, and it extends the whole length of the drives. It consists of kaolinised material intersected by numerous small quartz veins and leaders, in which occur visible gold.

No. 2 (85 feet level).—The crosscut from the shaft to this level is six feet to the West. From the crosscut a drive extends 98 feet to the South along the footwall of the reef, which is about from five to six feet in thickness. The 85 feet and 150 feet levels are connected by means of a winze situated at a distance of 50 feet to the South of the main crosscut. From this level a crosscut was put in to the East to cut the Eastern load and connect to the Eastern shaft. No defined quartz body was cut, though a distinct outcrop can be seen on the surface.

No. 3 (150 feet level).—At this level the crosscut to the shaft is only four feet in length to the West, showing that the incline to the East is four feet in 115 feet. Driving has been carried on to the South for a distance of 58 feet along the footwall of the reef,

the driving being exclusively in the stockwork, which was mined at this level for battery purposes.

Though the exact dimensions of this stockwork have not as yet been proved, sufficient development has taken place to show that to the 100 feet level it attains a considerable thickness, not less than 20 feet.

At the 100 feet level in the Southern shaft a crosscut was put in to test the Western outcrop. This crosscut extended for a distance of 132 feet, but did not pass through any body of quartz. A similar result was gained in making a crosscut 145 feet to the West from the 270 feet level of No. 4 shaft.

All these workings have been in compact hornblende rock, changing in places to hard, close-grained diorite, and have proved conclusively that the nature of the reefs on this property are of a decidedly lenticular nature. The output for the mine to date, as taken from official returns, is as follows:—Ore treated, 2,829 tons, giving a return of 858 ounces of gold, at the rate of 6dwts. 1gr. per ton. The average value of the gold is £2 13s. per ounce, giving a total value of £2,268 14s. 2d. to the amount of gold won.

Black Prince Gold Mining Lease 2208.

This property is situated in the North-East corner of the field, and has been prospected to some extent by three vertical shafts. There are two reefs running diagonally through the property past the South-West corner peg of Gold Mining Lease 2215. One of these reefs strikes East and West through No. 1 shaft, the other North-East and South-West through No. 2 shaft. Number 1 shaft has been carried to a vertical depth of 112 feet, and a parcel of 70 tons of ore stoped out between this and the 50 feet level. The reef is four feet in thickness, and for the 70 tons which were treated at the Northam Public Battery, yielded a return of 11dwts. per ton. This reef does not outcrop at the surface. The second reef runs through No. 2 shaft into the Black Prince No. 1 Gold Mining Lease 2215, where it has been opened out by three shafts; the vertical depths of which vary from 33 to 55 feet. Considerable quantities of copper carbonates impregnate the quartz here, and in some patches the copper ore predominates. The quartz does not outcrop in any continuous line at the surface, though floaters of quartz can be seen. The vertical depth of No. 2 shaft is 120 feet, at which level driving has been carried on to the East and West for a distance of 100 feet, and to the North and South 70 feet in

amphibolite rock. There has not been any stone treated by a battery from this second reef.

A statement as to the gold returns from these reefs has not been forwarded to the Department of Mines.

Cosgrove Bayley's Reward Gold Mining Lease 122.

Prospecting was formerly pursued on the Golden Bar and Great Hanover series of reefs, but on account of the great influx of water and the low grade of the ore these workings were abandoned. The present workings are on a reef running parallel to the main one, but lie some three chains to the East of the latter.

The strike of this second line of reef is North and South, with an underlie of 45° to the East. This reef has been opened in a very unsystematic style to the 116 feet level. Two drives on the bottom level, one 100 feet to the North and one 130 feet to the South, are still open, but the workings in the top levels have been filled in. The country rock throughout the mine is amphibolite, with the exception of the Northern face, which is hard compact diorite and apparently of a subsequent age. In this face the reef vanishes, it being faulted and thrown probably to the East. On the footwall of the reef the hornblende rock contains coarse gold in sufficient quantities to warrant its being mined and treated in the battery in preference to the quartz, which is of low grade. So far this auriferous hornblende rock has been proved to extend for a distance of from two to three feet on the footwall of the reef.

A main shaft is now being sunk on the underlay of the reef, *i.e.*, to the East, and eventually will be connected to the 116 feet level, from which the old workings will be systematically re-opened. The nature of the quartz in the reef is similar to many of the outcrops in the vicinity, and is white and opaque. In thickness the quartz body does not exceed two feet on an average. Between the 50 feet and 80 feet levels 340 tons have been stoped out and crushed, but the more profitable ore on the walls has not been touched.

From the first workings a plentiful supply of salt water may be obtained, and is calculated to be in excess of what would be required to supply a ten-head stamp battery.

From official records the output of the mine to date is 1,206 tons of ore treated for 912ozs. 4dwts. of gold, giving a rate of 15dwts.

3grs. per ton. The average value of the gold is £3 18s. $2\frac{1}{4}$d., giving a total value to the gold won of £3,565 11s. 0d.

Derby Mine Gold Mining Leases 1797 and 1798.

On Gold Mining Lease 1797 a shaft has been sunk to a vertical depth of 130 feet. Crosscutting was then proceeded with to the West for 135 feet, and to the East for 164 feet, at the 125 feet level.

At the end of the 164 feet crosscut, drives have been put in to the North and South for about 25 feet each way. From the end of the Southern one, a rise was then put up for 20 feet, and the drive continued to the South for 80 feet to connect with the shaft on Gold Mining Lease 1798. No defined reef or lode stuff was found in these workings, so that the leases were eventually abandoned. Potable water was struck in abundance at the 130 feet level.

Empress of Coolgardie Gold Mining Lease 1865.

The main shaft, which has a vertical depth of 212 feet, has now been abandoned, as the quartz reef, which was opened out extensively on the 120 feet level, proved to be almost barren. This reef runs parallel to the felsite dyke now worked by a party of miners who have taken the lease up "on tribute."

These workings are carried on in the open cut system, and so far have given satisfactory results. The strike of the dyke is North and South, with an underlie almost vertical. The width of the lode averages 20 feet. A five-head stamp battery is on the property, and affords means to crush the stone which is being mined.

The yield to date is 517ozs. 18dwts. 7grs. of gold from 1,383 tons of ore treated, giving an average of 7dwts. $11\frac{1}{2}$grs. of gold per ton. The gross value of this gold is £1,931 10s. $4\frac{1}{2}$d., the average value per ounce being £3 14s. $6\frac{3}{4}$d.

Flagstaff Gold Mining Leases 1604 and 1605.

At the time when I visited this mine exemption had been granted for several months and the mine shut down. The following information was given to me by the Manager in charge.

The outcrop of a well-defined reef is visible, extending through Gold Mining Leases 1604, 1605, and 3415 running parallel to the North and South boundaries of the leases. After entering Gold Mining Lease 3415, however, the reef bends round to the South-West, and from the strike of what outcrop is visible, will most

likely be found to pass through the Perseverance Extended (Gold Mining Lease 3252).

This lode has been opened out by three shafts which are connected with drives. Starting from the East the first shaft—Star shaft—has been sunk to a vertical depth of 116 feet. At this level a drive has been put in 33 feet to the East on the lode.

The central, or Ethel shaft, has a vertical depth of 160 feet. At the 60 feet level a drive has been made 160 feet West, and 100 feet East along the lode, which lies 11 feet to the South of the shaft, and is connected to the shaft by a crosscut.

The Annie shaft has a vertical depth of 112 feet. It is connected to the Ethel shaft at the 60 feet level by a drive 198 feet in length, and at the 100 feet level to both the Ethel and Star shafts by drives which follow along the lode.

Several short cuts are put in to the North and South from these shafts, but are of little importance, except to prove that the country rock is diorite.

The strike of the lode is North-East and South-West, with a slight underlie to the South-East. In thickness the lode is said to vary from four to 10 feet. The lode consists of clear glassy quartz, heavily charged with oxides and sulphides of iron. There are no crushing returns available to denote its quality as a gold producer.

The total output of this mine to date, as taken from official records, is 1,572ozs. won from 1,155 tons, or at the rate of 14dwts. 14grs. per ton. The average value of the gold per ounce is £3 12s. 6d., giving a gross value of £5,698 to the total output.

Forrest King Gold Mining Lease 284.

Two underlay shafts follow the reefs which underlie at a high angle to the East. The Southern one of these has a vertical depth of 115 feet. At the 50 feet level two drives have been put in to the North and South, the former extending for a distance of 28 feet to the North, with the latter 20 feet to the South.

In the Northern end of the drive the reef vanishes, but attains a thickness of from one to five feet in the shaft, and underlies at an angle of 60° to the East. The Northern underlay shaft is opened out at the 50 feet level with a drive extending 141 feet along the reef. At the end of this drive the reef ends. An old prospector's shaft is seen in this drive at a distance of 120 feet from

the underlay shaft. Descending to the 130 feet level, a winze follows the reef from the 50 feet level. The reef in this winze attains a thickness of six feet. Driving to the extent of 90 feet has shown the reef to have a thickness of from three feet six inches to four feet at the 130 feet level.

At the 170 feet level the reef has been opened out by drives extending to the South for 313 feet, and to the North for a distance of 256 feet from the main shaft. In the South drive the reef vanished at a distance of 150 feet from the main shaft. A crosscut was then put in to the East, and another reef was struck, striking at an angle of North 20° East and South 20° West. This reef is now being opened out to the South with rock drills, and shows a thickness of some five feet in the face. The country rock is diorite. At a distance of 134 feet from the main shaft, in the North drive, the reef also pinches out, but a quartz leader is seen bearing away to the North-East. This leader has been followed for some distance, as the walls were well defined, and there seemed great probability of finding another body of quartz to the East of the present main lode.

The vertical depth of the main shaft is 235 feet. A winze 134 feet to the North of the main shaft, on the 170 feet level, connects the 150 feet level to the 225 feet or bottom level, which latter is opened out to a distance of 134 feet to the North by a drive following the reef. The reef in this bottom drive has an average thickness of some four feet. The total yield, as gained from official returns, is 938ozs. 1dwt. 9grs. won from 1,362 tons 10cwt. of ore, or at the rate of 13dwts. 18grs. of gold per ton.

Golden Bar Gold Mining Lease 188H.

The Southern end of the Great Hanover line of reef passes through the centre of this property. No distinct outcrop of quartz is visible at the surface. The reef has been opened out from a main shaft. This shaft has been sunk for a vertical distance of 215 feet. In addition to sinking the shaft, the reef, which dips slightly to the West, has been opened out to some considerable extent at the 62 feet and 129 feet levels.

On the 62 feet level stoping has been carried to the surface from 80 feet along the drive to within some 30 feet of the main shaft. The reef along this drive is about 10 feet wide.

On the 129 feet level overhead stoping has been carried on from 114 feet along the drive to within some 20 feet of the main shaft, the quartz maintaining a thickness of about 4 feet.

The average strike of the reef is North 13° West, with an underlie of 1 in 8 to the West. Considerable difficulty in amalgamation is experienced, due to the presence of native copper in some considerable quantity.

A ten-head Fraser & Chalmers Mill has been erected, the Krupp Mill proving a failure for the class of stone treated.

A salt water supply is estimated at 23,000 gallons for every 24 hours.

Up to date official records show that 5,408 tons of ore have been treated, and have yielded 2,966ozs. 5dwts. 8grs. of gold, or at the rate of 10dwts. 23grs. per ton. The average value of the gold is £3 10s. 1¼d., giving a total value of £10,396 10s. 0½d. to the gold won.

Great Hanover Gold Mining Lease 3319.

This mine, on the day of my visit, was undergoing extensive alterations in the way of machinery erection. Owing to the influx of some 150,000 gallons of salt water per diem into the lower levels, it was found necessary to erect a large Cornish lift-pump. In consequence of the delay the mine was flooded, and it was impossible for me to descend. The following information was given to me by the manager (Mr. Thomas), and such, I have every reason to believe, is correct:—

The main shaft has been put down to prospect the most Eastern of the three reefs (the outcrops of which run North and South through the lease) and has been carried to a vertical depth of 250 feet.

The strike of the reef is North 10° West, with a slight underlie to the West. In thickness the quartz varies from six inches at the surface to three feet at the 250 feet level. The water level is at a vertical depth of 140 feet from the surface.

Eighty tons of quartz taken from the upper levels have averaged, on battery treatment, 15dwts. per ton.

The reef is in amphibole rock, and is in close connection with a felsite dyke—the same which passes through the Cosgrove Bayley's Reward and Bailey's United on the North, and the Golden Bar on the South. Unfortunately it is not possible to gain information as to the exact relation between these two, owing to the mine being filled with water. In consequence of the excessive quantity of water, the Big Blow (Gold Mining Lease 3590) and the

Herbert Consols (Gold Mining Lease 2885) have been able to draw a constant supply for battery purposes. Though too salt to be potable, this water is fresher than ordinary sea water, and contains about 2·5 per cent. of soluble salts only. The total output of gold to date, as taken from official records, is 185 tons of ore treated for 110ozs. 1dwt. of gold, or at an average of 11dwts. 21grs. of gold per ton of ore treated.

Hurtle Grove Gold Mining Lease 2755.

The only shaft on this property has a vertical depth of 100 feet with one level opened out at the 75 feet to the North and South for a distance each way of 35 feet.

The reef as seen here has a thickness of 3 feet, and runs North 20° East with an underlie of 70° to the East. An irregular outcrop of the reef is traceable at the surface. No crushings have been taken from this property.

The country rock is decomposed schist, which shows numerous slickensides. The lease has since been abandoned.

Lady Charlotte Gold Mining Lease 1384.

The reef which is being prospected on this lease does not outcrop very distinctly, though the underground workings prove its existence both in the Lady Charlotte and Duke of Wellington leases. All the underground workings are connected to one main shaft, which has a vertical depth of 300 feet. Levels are opened out at depths of 50, 75, 105, 198, and 300 feet.

Seventy-five feet level.—Starting from No. 2 shaft to the Southward, a reef continues for about 60 feet. At this point the drive discontinues, and a rise is put up to the 50 feet level. From No. 2 shaft a crosscut has been put in to the East for a distance of 20 feet, when the drive is continued to the North along the line of the main reef, which commences again 20 feet North of the crosscut, and continues for a distance of about 150 feet to the North, averaging eight inches in thickness. The stone in this drive shows coarse gold in places. The country rock is kaolinised material, the product of decomposed diorite. From the rise in the South end of the 75 feet level driving has been continued to the South, past the Duke of Wellington shaft*, on a 50 feet level.

Starting from this shaft a reef may be followed in the drive to the South for a distance of 55 feet, when it pinches out, nor is it again met with in any further workings to the South. At a

* For location of Duke of Wellington shaft, *vide* accompanying map.

distance of some 30 feet to the North of the shaft, however, a reef gradually widens out from a small quartz leader to a body at least two feet in thickness, and continues to some 220 feet to the North. Taking these reefs as they are seen in this mine, there can be little doubt of their lenticular nature, and whether they will re-make in harder country rock in the lower levels is a subject of much doubt, as there is no direct evidence on which to base an opinion either in this or the other mines of the field.

In the 84 feet crosscut on the 300 feet level the black bands are evidence, I take it, of the presence of a felsitic dyke, probably an extension of the one passing through the St. Simon (Gold Mining Lease 2419) to the North. If such be the case the Mount Charlotte reefs might be of a similar character to those in Bayley's United, which are also in close proximity to the seat of felsitic intrusions.

One hundred and five feet level.—The crosscut at this level from the main shaft to the lode is 15 feet in length.

In the south drive the cross reef found in the 198 feet level is met with at a distance of 60 feet from the main crosscut. Here, at the junction, as in the lower level, the main lode widens out considerably, but only continues a distance of 90 feet South, when, as below, it finally tapers out.

This South drive is continued for a total length of 212 feet, when a crosscut is put in a distance of 30 feet to the West, and the drive recontinued to the South for 50 feet, but no defined reef is cut. The 30 feet crosscut is continued for 30 feet more to the West, and a reef six inches is cut, but this reef so far has proved to be barren. The reef strikes North and South and underlies to the East.

One hundred and ninety-eight feet level.—The crosscut to the lode at the 198 feet level is 24 feet in length, and connects to a drive which extends 400 feet to the North. For 200 feet of this drive the reef averages about 15 to 18 inches in thickness, but afterwards tapers considerably. Its underlie is to the East at an angle varying from 45° to 70°. Going South from the crosscut a drive extends for 200 feet, after which the reef pinched so much that work in that direction was suspended. At a distance of 110 feet from the crosscut in this drive a cross reef striking North 40° East makes its appearance, but has not been followed to any distance. The underlie of the cross reef is 59° to the South-East.

The thickness of the reef in the South drive at the 198 feet level, varies from a few inches to six feet, the maximum thickness being near the intersection of the cross reef.

Three hundred feet level.—The working on this lowest level had not been carried on to any great extent, as the shaft had only recently been sunk. Crosscutting to the East for the reef, however, had been extended for a distance of 84 feet in hard, compact, diorite country, but no regular reef has been cut, though patches of quartz were met with, and bands of the dark rock resembling slate, which is so often found associated with the felsitic dykes.

Up to the present crushings have not been made of the ore in this mine, though the reef is so opened out that large quantities of quartz can easily be supplied when required.

Lady Loch Gold Mining Lease 336.

The main reef on this property strikes East and West, and is almost vertical, but has a slight dip at times to the South. A whip-shaft, due North of the main shaft, has a vertical depth of 100 feet. At this level a drive has been opened out to a distance of 480 feet to the East.

Following along this drive, the Lady Loch reef is seen to have a thickness varying from six inches to four feet, but pinches out at a distance of 180 feet East of the whip-shaft. At a distance of 270 feet East from the whip-shaft a larger reef makes its appearance, and follows along the same strike as the first, but underlies to the North. The average thickness of this reef is two feet. To the West of the whip-shaft the main reef is seen to continue for a distance only of 120 feet. Stoping from this level to the surface has been completed for distances of 110 feet West and 180 feet East of the whip-shaft. The appearance of this stone is white and vitreous, while that of the Eastern reef is very white and semi-granular.

The vertical depth of the main shaft is 150 feet, and is connected by a crosscut to the 150 feet level by a crosscut 65 feet in length to the North.

Driving along the reef at the 150 feet level has been carried on 105 feet West and 175 feet East of the crosscut. A winze has been sunk to a depth of 100 feet at a position 100 feet to the East of the crosscut, but is now filled with water, so that I could not gain information as to the occurrence of the reef at a lower level than 150 feet. The reef at the 150 feet level is inclined to dip to the North, like the Eastern reef.

Work was suspended on this mine at the time of my visit. A small cross reef, which has been slightly exposed at the surface, strikes across from the Lady Loch to the Forrest King reefs, but, up to the present, has not been opened out underground.

The country rock in this mine is diorite, of a similar nature to the prevailing diorite found elsewhere on the field. The total amount of gold won from this reef is 5,260 ounces, obtained from 1,697 tons of ore. The average rate of gold per ton is 3ozs. 1dwt. 23grs.

Macpherson's Reward Gold Mining Leases 664 and 1739.

The line of reef worked on this property strikes North-North-West and South-South-East, and underlies at an angle of 45° to the East. No distinct outcrop is visible at the surface. Two underlay shafts (Nos. 2 and 3) to the 60 feet level, and a vertical shaft with a depth of 185 feet, have been sunk, and levels opened out principally at the 60 feet and 177 feet levels. Taking the 60 feet level first, this is found to follow the reef for a distance of 240 feet to the North-West, when the reef tapered to a mere leader. At a distance of 80 feet from main shaft, a winze has followed the reef to a distance of 30 feet from the 60 feet level. Also at a distance of 30 feet a winze follows the reef to the 80 feet level, which is opened out to the North-West by a drive of a few feet in length. A crosscut to the North-East has passed through diorite for a distance of 108 feet.

Except several minor drives and crosscuts at the 50ft., 90ft., and 110ft. levels the workings on the 60ft. level comprise all that has been done to open out the reef as yet. Stoping between the two underlay shafts has been carried on from the 60ft. level to the surface, and it is in this spot that the richest part of the lode was found. For this short distance the reef averaged 20 inches in thickness, but afterwards tapered very much when followed to the North. The quartz is of a white vitreous nature. Development has so far proved the country rock to be diorite or amphibole rock.

The returns from 1,623 tons 15cwt. of ore crushed from this mine, were 1,359oz. 6dwts. 4grs., giving an average of 16dwts. 10grs. of gold per ton of ore treated. The average value of the gold is £3 16s. 2d., giving a gross value of £5,177 0s. $7\frac{3}{4}$d. for the gold won.

Mount Rowe Gold Mining Leases 1004, 754, 988, and 621.

The reef which runs through this lease is probably a continuation of the line of reef extending Northward through the "No Gammon" (Gold Mining Lease 1019), to which an indistinct outcrop can be partially traced.

Two levels have been opened out at the 150 and 207 feet levels from a shaft with a vertical depth of 223 feet 8 inches. These workings are carried on to prospect a felsitic lode and a quartz reef which cut through the shaft at the 150 feet level. Starting with this level, which has been opened out to the South of the shaft, a mixed lode of felsite and quartz and a quartz reef have been followed for a distance of 250 feet. The reef for this distance varies in thickness from four to seven feet; the lode from 10 to 15 feet. The strike of the lode is South 25° East. Some 28 feet to the South of the main shaft a branch reef joins the main lode, the trend of this latter being at first North-East, but afterwards it turns to the North and assumes a North 25° East strike for a distance of some 100 feet, when it gradually tapers out. This branch reef averages about two feet in thickness, and dips to the East. At a distance of 80 feet from the junction with the main reef, the branch reef itself branches off to the North-West, having a strike of North 30° West, but does not continue for more than some 30 feet in this direction.

From the shaft a crosscut to the East has been made for a distance of 140 feet. This crosscut cuts the branch reef at a distance of 20 feet from the shaft. The felsitic lode and associated quartz reef have not been opened out to the North on this level.

At a distance of 100 feet North from the main shaft, *i.e.*, at the end of the North drive, a small cross reef is followed along an apparent line of fault striking East 50° North. This fault will be found, I think, to connect the felsite lode to the felsitic dyke seen outcropping to the East, higher up on the side of Mount Rowe. In appearance the quartz reefs are white and glassy.

Two hundred feet level.—At this level a crosscut has been made in massive hornblende rock of a very fine grained and extremely hard nature, but no reefs have been cut in the 170 feet opened out.

In a crosscut to the East the felsite lode is met with at a distance of 10 feet from the main shaft, and has been followed at this point for a distance of 75 feet in a winze which underlies to th

East at an angle of about 1 in 5. The formation has also been followed in a drive for a distance of 60 feet to the South.

In the crosscut, and at a distance of 37 feet East from the main shaft, a reef averaging about one foot in thickness was cut. This is probably the branch reef of the upper level, but has not been followed any distance to the North and South. Its dip and strike correspond to that of the branch reef of the 150 feet level.

No crushings have been made of the ore in this mine.

New Australasian Gold Mining Lease 1093.

This mine forms perhaps the most noted example of the lenticular nature of some of the quartz bodies in the Coolgardie Goldfield, inasmuch as the whole of the quartz has been removed, and no direct indications of a continuation of the deposit can be discovered. The trend of the drives shows that the strike of the lode was practically North and South, while the direction of the winzes points to an Easterly dip. The lowest level is 249 feet below the surface, but Diamond Drill bores have increased this to a depth of about 500 feet. So far the cores from these bores show that the country rock below the 249 feet level is hornblende rock, with occasional patches of carbonate of lime, and in one or two instances narrow quartz leaders.

Crystals of pyrites were common in parts of some of the cores. To the 200 feet level the country rock is decomposed diorite, but between the 200 feet and 250 feet levels extremely hard compact hornblende rock made its appearance. The following are the complete returns to the end of the year 1897, as furnished by the Company's office. Two thousand eight hundred and eleven tons of ore treated for a return of 7,239 ounces of gold, giving a gross value of £26,093 15s.

In addition to these the official returns for the year 1898 give an output of 1,427ozs. 6dwts. 12grs. from 195 tons, making a gross return of 8,666ozs. 6dwts. 12grs., won from 3,006 tons, or at the rate of 2ozs. 17dwts. 15grs. per ton.

Perseverance Extended Gold Mining Lease 3252.

Probably the same reef which passes through the Bird in the Hand (Gold Mining Lease 2080) to the Flagstaff (Gold Mining Lease, 2753) has been worked in the main shaft of this lease.

The main shaft is down to a depth 150 feet, and the reef has been opened out at the 60, 100, and 150 feet levels by drives

extending North and South each way for a distance of 50 feet on the three levels. The strike of the reef is North 20° East, with an underlie of 1 in 15 to the East. The quartz is of a milky white appearance, and of low grade.

A second shaft to the East of the main shaft is down 75 feet on a felsite dyke, which contains small quartz leaders carrying gold. The felsite rock has decomposed into a soft kaolin, and is easily mined. It is undoubtedly a continuation of the felsite dyke running North from the Golden Dyke (Gold Mining Lease 2080).

The yield of gold from this mine to date is 6ozs. from 55 tons of ore treated, yielding an average of 2dwts 4grs. per ton.

Queensland-Coolgardie Gold Mining Lease 3573.

A reef runs through the centre of this lease in an almost North and South direction. Though the outcrop can be followed on the surface, the reef is not well defined till the lower levels are reached.

The main shaft has a vertical depth of 133 feet. At the bottom level a crosscut 24 feet in length to the East connects the shaft to the main drive at the 133 feet level. This drive follows a reef which strikes North 10° West, and underlies to the East at an angle of 65°. Following along this drive to the North a winze is first passed which has been sunk on the reef to a depth of 40 feet. The drive is then continued for 120 feet further, when a crosscut to the West connects the present workings to the old prospecting shaft which is 27 feet along the crosscut. The crosscut has been continued 60 feet further to the West of the prospecting shaft.

The reef along the main drive is very variable in thickness, ranging from a width of a few inches to several feet, and averaging about one foot six inches to two inches for the whole distance. The quartz is white and of a more or less granular appearance. It carries coarse gold in many places, and gives every promise of being payable. The country rock is amphibolite, and is unoxidised even at the surface.

On the Eastern side of the lease is another line of reef which follows parallel to a felsitic dyke, but so far prospecting has not been carried on to any extent on this lode, which, at the surface, does not give encouraging prospects. The strike of both reefs is slightly to the West of North, with a dip of 65° to the East.

The total yield of gold as taken from official records for this mine is 270ozs. 3dwts. 8grs., won from 218 tons 10cwts. 1qr., or at the rate of 1oz. 4dwts. 17grs. per ton.

Rose Hill Gold Mining Lease 1599.

The workings on this lease are in a decomposed kaolinised rock, probably altered felsite, intersected by numerous quartz leaders containing gold. The strike of the lode is North 60° West, and underlies to the North-East at an angle of 71°. In character the walls vary from amphibole rock to a coarse-grained diorite. The lode has been followed in a vertical shaft to 183 feet beneath the surface, at which level its character is entirely different, the quartz veins having apparently collected into more or less irregular quartz masses in which both free gold and pyrites are visible.

The encasing rock, too, is auriferous, and is treated with the quartz for a variable distance on either side of the quartz. Both the quartz and the walls are impregnated with pyrites.

Noting the gradual change from the surface, there seems every probability of the quartz eventually turning into a true quartz reef. Crosscuts to the West for 57 feet and to the North-East for 45 feet have been put in at the 183 feet level. In the latter the lode was struck, and proved to be from eight feet to ten feet in thickness.

As the end of the 45 feet drive was on the boundary of the Killarney (Gold Mining Lease 3070), further development was suspended. At the 80 feet level considerable development has taken place, the lode opening out to a width of 60 feet.

The supply of water (which is salt) averages from 15,000 gallons to 20,000 gallons per diem.

A great change in the country rock takes place after sinking below the water level, fine-grained diorite taking the place of the amphibole rocks and coarser-grained diorites. The lode consists of a kaolinised rock through which run small quartz leaders. Such evidence as there is tends to the probability of this lode being part of a felsite dyke similar to those already described in other mines on this field.

The total output to date is 364 tons crushed for a return of 185ozs. 1dwt. 20grs., or at the rate of 10dwts. 4grs. per ton. The

value of the gold is £3 15s. per ounce, giving a total value of £694 1s. 10½d. to the gold won.

St. Simon Gold Mining Lease 2419.

The principal workings on this lease consist of two vertical shafts which have been sunk to prospect a felsite dyke through which run small veins of quartz carrying gold. No outcrop of the lode is visible at the surface.

In the South shaft, which has a vertical depth of 150 feet, two crosscuts have been put in to the East and West simply to prospect the surrounding country. Of these the Eastern one extends for a distance of 200 feet from the shaft, while the other follows parallel to the Southern boundary of the lease for a distance of about 300 feet. At a distance of 180 feet in the East crosscut a felsite dyke has been cut, otherwise the country consists of diorite. In the Western crosscut occasional quartz leaders striking North and South and underlying at variable angles to the East were passed through.

A main drive partly following the felsite lode extends to No. 3 shaft. The strike of this lode is North and South for about 80 feet, but after this it turns away to the West. The average thickness of the lode is about 10 feet.

Number 3 shaft is also connected to the No. 1 shaft at the 85 feet level, but reveals no change of importance. The felsite lode will be found to continue far away to the North, passing through the Oriental (Gold Mining Lease 618) and Orient (Gold Mining Lease 3338). To the West of this lode is a large quartz reef passing through Gold Mining Leases 618 and 3338. In Gold Mining Lease 3338 this reef is found in closer proximity to the felsite lode, and will eventually be found occurring in association with the latter, like similar lodes and felsite dykes in other parts of the field. Prospecting had been suspended in these particular workings of the St. Simon (Gold Mining Lease 2419) at the time of my visit, as the prospecting had been concentrated on the Lady Charlotte (Gold Mining Lease 1384). No crushing of any of the ore has been made up to the present.

Sherlaw's Perseverance (Gold Mining Lease 3415).

No distinct outcrop of the main reef of this lease is visible, though the workings have proved the continuity of the quartz vein

for a considerable distance underground, in a line running parallel to the Western boundary.

Two other reefs, which are still unprospected, run parallel to this main line, but are near the Eastern boundary.

The main shaft has been sunk to a vertical depth of 414 feet on the Western lode, and is one of the deepest workings on the field. Levels have been opened out at vertical depths of 100, 200, 300, and 414 feet.

One hundred feet level.—Two drives have been opened out at this level to the North for 264 feet, and to the South for 150 feet following along the reef. In the Southern face the reef tapers out, and is of very small dimensions throughout the whole length of this and the Northern drive at this level. In consequence, work has been suspended in this portion of the mine, and development carried on more extensively at the lower levels. The 100 feet level is perfectly dry, and in the oxidised zone. The strike of the reef is North 30° East, with a very slight underlay to the West.

Two hundred feet level.—Drives extending 154 feet to the North and 143 feet to the South open up the reef at this level. The drives lie six feet to the East of the main shaft, and are connected with the latter by means of a small crosscut. This level is the lowest one in the oxidised zone, sulphides occurring at no great depth beneath. The quartz vein, though continuous, is narrow and of low grade, so that work in this level too has been suspended.

Three hundred feet level.—At this level the reef cuts through the shaft, and attains a thickness there of some 12 feet. From here the reef has been followed for a distance of 70 feet by means of a drive, in the face of which the reef has a thickness of two feet. At a distance of 47 feet South from the main shaft, a calcite band is seen to cross the reef striking North-West and South-East, and dipping at a high angle to the South-West. In the vicinity of this band, which is also met with in the next level, richer stone usually occurs. Iron pyrites and pyrrhotine are of common occurrence in the ore at this level. Free gold is also sometimes visible. The country rock throughout the mine is diorite.

Four hundred and fourteen feet level.—In this level the reef strikes North 30° East, and underlies at an angle of 85° to the West. Drives have been extended 110 feet South and 40 feet to the North along the reef. These drives are connected to the main shaft by

means of a crosscut extending 12 feet to the West from the shaft. In the Southern drive on this level, at a distance of 86 feet from the shaft, the reef has been broken, and a subsequent deposition of calcite and gypsum taken place. The trend of this latter deposit is North-West and South-East, and has a thickness of some six feet. The faulted or Southern portion of the reef has been thrown several feet to the East. Throughout this lower level the reef maintains an average thickness of eight feet, and shows no signs of tapering out in either face. Considerable change in the quality of the reef has taken place at a depth, the returns obtained from crushing and concentrating being much greater than those from the 100 feet and 200 feet levels. Great difficulty has been experienced from lack of water on this property, and the irregularity of supply from other sources. So far the ore has been treated on the ground by means of a ten-head stamp battery. In appearance the ore is white and vitreous, and heavily charged with pyrites below the 200 feet level. The following are the official returns of the output of gold to date:—Crushed 4,752 tons, for a yield of 3,015ozs. 19dwts. 12grs., at the rate of 12dwts. 16grs. per ton. The average value of the gold is £3 8s. 2d. per ounce, giving a gross value of £10,281 0s. 10½d. to the gold won.

Steadman's Choice Gold Mining Lease 2725.

There are apparently two lines of reef on this property running almost parallel in a North and South line, but having variable underlies. Prospecting had not been extended far enough for the junction of the two reefs to be determined. The old workings, which are on the Western outcrop, have been carried on to a small extent by means of two prospecting shafts, which were not accessible to me. On the Eastern line a main shaft has been put down in diorite country to a depth of 150 feet, which depth is slightly below the water level. The influx of salt water is about 1,000 gallons per 24 hours. In passing down the shaft the reef is seen at the 100 feet level, and is of some considerable thickness with a slight dip to the West.

The quartz in this reef is highly charged with pyrites, but is said to yield satisfactory assays. Further development is to be carried on at the lowest level of the main shaft. The long line of reef extending in an East and West direction through the Southern portion of Gold Mining Lease 2725 has been prospected to a very small extent and then abandoned. The outcrop of this reef is

sometimes at least 16 feet in thickness, but has a barren, white, semi-opaque appearance.

Nineteen tons 19cwt. of ore from this mine were crushed at the Golden Bar Battery, and yielded 9ozs. 10dwts. 7grs., or 9dwts. 13grs. of gold per ton of ore treated. The value of the gold is £3 17s. 6d. per ounce.

Tartar Gold Mining Lease 2769.

This property is on the same line as the Hurtle Grove and Balmoral Castle Leases, and has, since my visit, been abandoned. The old workings consist of two shafts, the most Northern of which is 100 feet in depth, with a drive to the East for 30 feet. The reef in the end of this drive is some 20 inches in thickness, and runs North and South with an underlie of 70° to the East. The second shaft was sunk on the underlie of the reef for a depth of 50 feet, and then a crosscut was put in 30 feet to the West. The country rock is decomposed schist. Up to the date of my visit to this mine no crushings of the reef had taken place.

Tindal's Gold Mining Lease 33.

At the date of my visit the old workings, which had opened up a large quartz reef, had been abandoned, and a fresh start made by a party of miners "on tribute," who recommenced work in an "open cut" on the auriferous felsite dyke running parallel to the reef. This dyke, which attains a thickness of some two chains, runs North and South, and dips to the West at an angle of 35°. It is evidently a small branch of a larger dyke which strikes North and South throughout the property. Along the South-East boundary of the lease a fault occurs in the latter, the Southern portion, which passes through the Golden Dyke Gold Mining Lease 2080, being thrown slightly to the South-West. So far the returns from ore taken from the open cut have averaged 8dwts. per ton. The water used for the five-head stamp battery is taken from the shaft on the Eastern side of the lease.

The following is the total gold output to the end of the year 1898:—Crushed 4,594 tons of ore, which yielded 1,311oz. 19dwts. 14grs. of gold, giving an average of 5dwts. 17grs. of gold per ton of ore treated.

Union Jack Gold Mining Lease 1385.

The shafts on this property are four in number. Of these the main shaft has a vertical depth of 172 feet, and has been sunk on

the Eastern branch of a line of reef running North 20° West through the centre of the Union Jack and Ensign (Gold Mining Leases 1385 and 1953). The strike of the Eastern branch is North and South, with an underlie of 80° to the West. Both reefs outcrop at the surface, the main line in particular being traceable by a large body of quartz appearing several feet above the surface. The continuation of this outcrop is of short duration. At the 100 feet level in the main shaft a 30 feet crosscut to the reef has been made in hornblende rock. The reef here attains a thickness of 10 feet. A similar crosscut at the 160 feet level is 53 feet in length, and passes through hornblende rock. The reef is five feet six inches in thickness at the end of this crosscut. Driving to the extent of 100 feet North on the 100 feet level, and 35 feet North on the 160 feet level along the reef, comprise the underground workings. Work was suspended at the date of my visit. The country rock is diorite, changing in places to an amphibole rock. Galena is visible in the quartz (which is of a glassy white nature) and is considered a good indicator of the richer portions of the reef. In some stone from the workings of the Ensign (Gold Mining Lease 1953) which had been shut down, some small pieces of molybdenite were found, but the relation of this mineral to the lode was not ascertainable.

The total yield to date of stone treated from the Union Jack (Gold Mining Lease 1385), according to official returns, is as follows:—477 tons 10cwt. yielded 522ozs. 9dwts. 18grs. of gold, the rate per ton being 1oz. 1dwt. 21grs. In value the gold averages about £3 13s. 4d. per ounce.

Gold Production.

It will probably be noticed that there is a discrepancy of 278,869 ozs. between these Returns and the amount of Exported Gold as furnished from the Customs House.

This difference in amount may be accounted for partly by its not being compulsory to furnish returns of the alluvial gold won, and from the difficulty of obtaining statements of the output of quartz claims. As, however, the greatest difference arises in the Returns previous to the year 1897, it will probably be found to be due to mistakes arising confusing the different Goldfields, as it was about this time that the Coolgardie Goldfield was sub-divided into the East and North-East Coolgardie Goldfields. The difference between the two sets of Returns may also be due to the fact that a good deal of gold won in the early days of the field was not reported

to the Mines Department. The following is a comparative table, and will show the variation in the discrepancy :—

Amount of Gold entered for Export.		Amount of Gold as supplied to the Department of Mines in Quarterly Statements.	
Date.	Ozs.	Date.	Ozs.
Previous to 1897 ...	299,571	Previous to 1897 ...	66,691
1897	104,306	1897	64,555
1898	127,227	1898	110,989
Total	521,104	Total	242,235

Difference 278,869 ounces.

Return showing the Yield of the Leases on the Coolgardie Goldfield.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold.		Value of Gold.	
				Total Yield.	Rate per ton.	Total Value.	Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
464s	Admiral Dewey	1898	26 0 0	36 9 0	1 8 0	142 3 1	3 18 0
3676	Admiral Sampson	1898	44 0 0	18 0 15	0 8 5	70 15 5¼	3 18 6
319s	A Golden	Previous to 1897	0 2 0	50 0 0	500 0 0		
	Do.	1897	14 0 0	127 0 0	9 1 10		
		Total	14 2 0	177 0 0	12 11 1		
2613	Auckland	Previous to 1897	50 0 0	24 13 0	0 9 20		
3608	Aurum	1898	61 0 0	49 19 0	0 9 19	172 16 10	3 10 0
3668	Australasian Junction	1898	15 0 0	7 3 0	0 9 12	27 3 4¾	3 16 0
538	Australasian United	1898	43 5 0	21 17 0	0 9 1½	81 18 9	3 15 0
463s	Bantam	1898	40 10 0	33 8 6	0 16 7		
1988, 1989	Bass and Flinders	Previous to 1897	10 0 0	5 10 0	0 11 0		
22	Bayley's Consols (No. 2 South)	1897	852 0 0	455 18 0	0 10 16	1774 16 5	3 17 10½
	Do.	1898	3125 0 0	1932 0 0	0 12 8	7522 14 6	3 17 10½
		Total	3977 0 0	2387 18 0	0 12 0	9297 10 11	3 17 10½
133, 139	Bayley's Reward	Previous to 1897	13312 0 0	35287 0 0	2 13 3	137325 4 10	3 17 10
142, 157	Bayley's United G.M. Co.	1897	1397 0 0	3533 0 0	2 10 13	13749 5 2	3 17 10
	Do.	1898	3961 3 1	14429 0 0	3 10 8	56252 17 2	3 17 10
		Total	18670 3 1	53249 0 0	2 17 0	207327 7 2	3 17 10

471	Bayley's South Extended	1897	47 0 0	8 11 0	0 3 15		
207, 423	Bayley's South, Number 2 ...	Previous to 1897	100 0 0	29 0 0	0 5 11	90 0 5	3 2 1
	Do.	1897	514 0 0	312 16 0	0 12 4	970 19 7	3 2 1
		Total	614 0 0	341 16 0	0 11 3	1061 0 0	3 2 1
351, 724	Bendigo and Coolgardie Proprietary G.M. Co.	1897	263 0 0	296 7 0	1 2 12	1148 7 1¼	3 17 6
	Do.	1898	730 0 0	921 15 9	1 5 1		
		Total	993 0 0	1218 2 9	1 4 13		
295s	Belavon	1897	48 0 0	51 4 0	1 1 8		
35	Big Blow (Coolgardie)	Previous to 1897	154 0 0	71 0 0	0 9 4	188 3 2	2 13 0
	Do.	1897	265 0 0	124 0 0	0 9 8	328 12 0	2 13 0
	Do.	1898	2410 0 0	663 0 0	0 5 12	1751 19 0	2 13 0
		Total	2829 0 0	858 0 0	0 6 1	2268 14 2	
439s	Big Blow (Kunanalling)	1898	85 15 0	72 9 4	0 16 19	282 11 8¾	3 18 0
162s	Blackett's Gold Mines	1897	334 12 0	318 5 13	0 19 0	1113 19 4¾	3 10 0
71s	Do.	1898	478 13 0	255 19 0	0 10 15	991 16 1½	3 17 6
		Total	813 5 0	574 4 13	0 14 2	2105 15 6¼	3 13 3½
3631	Blue Peter	1898	118 0 0	77 10 0	0 13 3	301 15 3¾	3 17 10½
3542	Bobbie Dazzler	1897	Specimens	54 6 12			
2146	Bonnie Vale	1898	363 12 0	186 16 0	0 10 5½	671 3 0¾	3 11 10
3066	Breakespeare	1897	16 0 0	34 8 0	2 3 0		
35s	Brevier	1897	70 0 0	33 0 0	0 9 10	132 0 0	4 0 0
11s	Brevier No. 2	1898	34 10 0	17 5 22	0 9 20	67 5 3¼	3 17 10½
3618	Brilliant	1898	102 0 0	101 0 0	0 19 19	379 9 1	3 15 1½
444s	British Lion	1898	34 0 0	57 18 0		...	3 15 4½
193, 1624	Briton's United	Previous to 1897	36 0 0	27 0 0	0 15 0		

Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold. Total Yield.	Yield of Gold. Rate per ton.	Value of Gold. Total Value.	Value of Gold. Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
458s	Broncho	1898	40 0 0	17 13 4	0 8 19		
119s, 181s	Bunyip	Previous to 1897	100 0 0	213 5 0	2 2 5		
2210	Burbank's Consols	1898	18 0 0	14 19 0	0 16 14		
1799	Burbank's Grand Junction	Previous to 1897	362 0 0	1385 0 0	3 15 18	5286 1 8	3 16 4
	Do.	1897	100 0 0	258 0 0	2 11 14	978 5 0	3 15 10
	Do.	1898	415 0 0	567 5 0	1 7 7	2239 5 6	3 18 0
		Total	877 0 0	2210 5 0	2 10 10		
3632	Burbank's Horseshoe	1898	11 0 0	67 14 22	6 3 4		
3627	Burbank's Ivanhoe	1898	88 0 0	52 2 0	0 12 6	195 11 10	3 15 1
3444	Burbank's Main Lode	1898	90 0 0	88 1 0	0 19 13¾	330 3 9	3 15 0
3200	Burbank's Star	1897	87 0 0	85 12 0	0 19 16		
134, 135	Burbank's Birthday Gift	Previous to 1897	1822 0 0	7136 10 0	3 18 8	26761 17 6	3 15 0
	Do.	1897	6190 0 0	13453 8 18	2 3 10	50450 7 9¾	3 15 0
	Do.	1898	11414 0 0	16970 3 5	1 9 18	63638 2 0¼	3 15 0
		Total	19426 0 0	37560 1 23	1 18 17		
152s	Camperdown	Previous to 1897	0 1 0	100 0 0			
1959, 1630	Cardiff Castle	Previous to 1897	1350 0 0	254 12 22	0 3 18		
86s	Caroline	1897	6 0 0	39 16 0	6 12 16	161 3 9	4 1 0
123s	Castle Hill	1898	101 0 0	143 12 0	1 8 11	572 17 0	3 19 8
404s	Castle View East	1898	152 10 0	73 16 6	0 10 6	278 12 10½	3 15 6
161s	Catherine	1898	4 0 0	8 11 4	2 2 19	33 9 8	3 18 3
113s	Central Wealth Consolidated	1898	229 0 0	313 15 8	1 7 9		
1852, 2168	Charing Cross	Previous to 1897	10 0 0	15 10 0	1 11 0		

3460	Cheapside	1897	59 10 0	69 10 4	1 3 4		
	Do.	1898	264 0 0	240 19 0	0 18 6		
		Total	323 10 0	310 9 4	0 19 5		
64s	City of London	1897	406 0 0	486 17 0	1 3 23	1451 8 5	2 19 7½
	Do.	1898	313 0 0	186 0 11	0 11 20		
		Total	719 0 0	672 17 11	0 18 17		
84	Clyde	Previous to 1897	102 0 0	91 0 0	0 17 20		
	Do.	1898	740 0 0	231 3 0	0 6 5¾	901 4 1	3 17 11½
		Total	842 0 0	322 3 0	0 7 15		
3602	Condenser King	1898	209 10 0	184 11 21	0 17 13	718 15 2½	3 17 10½
3524	Coonong	1898	39 0 0	10 14 0	0 5 11¾	40 2 6	3 15 0
432s	Corneuba	1898	12 0 0	6 0 0	0 10 0	25 5 0	3 17 6
122	Cosgrove Bayley's Reward	Previous to 1897	150 0 0	37 0 0	0 4 22	144 1 4½	3 17 10½
	Do. do.	1897	112 0 0	142 5 0	1 5 9	553 17 8½	3 17 10½
	Do. do.	1898	944 0 0	732 19 0	0 15 12	2867 11 11	3 18 3
		Total	1206 0 0	912 4 0	0 15 3	3565 11 0	3 18 2¼
445s.	Daisy Bell	1898	20 10 0	28 14 0	1 7 9	111 4 3	3 17 6
115s.	Dark Horse	1898	4 4 0	277 1 19	65 19 1		
428s.	Daybreak	1897	28 0 0	42 10 0	1 10 8		
	Do.	1898	25 9 0	50 7 0	1 19 13		
		Total	53 9 0	92 17 0	1 14 10		
1854	De Beers...	1897	3 0 0	4 10 0	1 3 8		
3621	De Beer's West	1898	10 0 0	3 1 0	0 6 2	12 4 0	4 0 4

Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold. Total Yield.	Yield of Gold. Rate per ton.	Value of Gold. Total Value.	Value of Gold. Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
225s., 241s.	Denver City	1897	32 0 0	121 7 0	3 15 15		
	Do.	1898	74 3 0	279 2 12	3 15 10		
		Total ...	106 3 0	400 9 12	3 15 13		
1555	Dunallan No. 1	1897	17 15 0	5 8 0	0 6 2		
15s.	Eclipse	1898	50 0 0	34 12 13	0 13 20	134 16 $6\frac{3}{4}$	3 17 $10\frac{1}{2}$
3251	Eldorado	Previous to 1897	76 0 0	18 9 3	0 4 20		
2926	Elvira	1898	74 0 0	15 0 0	0 4 1	45 0 0	3 0 0
1982s.	Emu	1898	102 0 0	146 16 9	1 8 19	587 5 6	4 0 0
1598	Emperor	1898	5 0 0	1 3 0	0 4 $14\frac{1}{2}$	4 12 0	4 0 0
1865	Empress of Coolgardie	1897	472 0 0	101 19 0	0 4 7	382 6 3	3 15 0
	Do.	1898	911 0 0	415 19 7	0 9 3	1549 4 $1\frac{1}{2}$	3 14 $5\frac{3}{4}$
		Total ...	1383 0 0	517 18 7	0 7 $11\frac{1}{2}$	1931 10 $4\frac{1}{2}$	3 14 $6\frac{3}{4}$
3453	Enterprise	1897	1120 6 0	691 1 18	0 12 8	2637 13 0	3 16 4
	Do.	1898	306 0 0	153 6 12	0 10 $0\frac{1}{2}$	598 6 $4\frac{1}{4}$	3 18 $0\frac{1}{4}$
		Total ...	1426 6 0	844 8 6	0 11 20	3235 19 $4\frac{1}{4}$	3 16 7
1604, 1605	Ethel Flagstaff Gold Mining Company	Previous to 1897	90 0 0	46 0 0	0 10 5	166 15 0	3 12 6
	Do.	1897	2065 0 0	1526 0 0	1 8 15	5531 5 0	3 12 6
		Total ...	2155 0 0	1572 0 0	0 14 14	5698 0 0	3 12 6

34s	Fair Adelaide	Previous to 1897	10 0 0	16 0 0	1 12 0		
	Do.	1897	8 0 0	7 9 0	0 18 15		
		Total	18 0 0	23 9 0	1 6 1		
260s	Fitzroy	1898	58 0 0	17 11 21	0 6 1	30 13 1½	3 15 0
284	Forrest King	Previous to 1897	697 0 0	472 0 0	0 13 13		
	Do.	1897					
	Do.	1898	665 10 0	466 1 9	0 13 23	1807 3 4¼	3 17 7
		Total	1362 10 0	938 1 9	0 13 18		
53s	Fremantle Consols	1897	40 0 0	243 10 0	6 1 18		
	Do.	1898	94 1 0	144 0 0	1 10 15	576 13 10¼	4 0 0¼
		Total	134 1 0	387 10 0	2 7 20		
3617	Garfield	1898	40 0 0	65 6 0	1 12 15½	253 2 6	3 17 5¾
595	Gem	1897	360 10 0	336 10 0	0 18 15	1278 14 0	3 16 0
	Do.	1898	3179 0 0	1765 12 8	0 11 2	6400 10 9¾	3 12 6
		Total	3539 10 0	2102 2 8	0 11 21	7679 4 9¾	3 13 0¾
3630	Gem of the Vale	1898	24 2 0	9 7 9	0 7 18		
261s	General Lee	1897	20 0 0	11 7 0	0 11 8		
12s	Gladstone Extended	1897	80 0 0	23 0 0	0 5 18	320 0 0	4 0 0
717, 1149	Gleeson's Success	1897	143 0 0	177 3 0	1 4 18		
	Do.	1898	295 0 0	374 11 0	1 5 9	1433 7 0	3 16 6
		Total	438 0 0	551 14 0	1 5 4½		

Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold. Total Yield.	Yield of Gold. Rate per ton.	Value of Gold. Total Value.	Value of Gold. Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
1918	Glenloth South	1897	329 0 0	468 4 0	1 8 11		
	Do.	1898	43 0 0	47 0 0	1 1 20¾	182 2 6	3 17 6
		Total	372 0 0	515 4 0	1 7 16		
424s	Glenmore	1898	98 10 0	169 17 0	1 14 7	655 11 8½	3 17 1½
20	Golden Bar	Previous to 1897	110 0 0	79 12 0	0 11 12	278 12 0	3 10 0
	Do.	1897	1945 0 0	1132 5 0	0 11 15	3962 17 6	3 10 0
	Do.	1898	3453 0 0	1754 8 8	0 10 20	6155 1 6½	3 10 2
		Total	5408 0 0	2966 5 8	0 10 23	10396 11 0	3 10 1¼
49s	Golden Crest	Previous to 1897	10 0 0	5 0 0	0 10 0		
	Do.	1898	405 0 0	89 3 18	0 4 9		
		Total	415 0 0	94 3 18	0 4 2		
1405	Golden Drop	1897	283 10 0	269 4 0	0 18 22	1022 19 2¼	3 16 0
	Do.	1898	899 0 0	540 16 5	0 12 0	1960 8 8¾	3 12 6
		Total	1182 10 0	810 0 5	0 13 16	2983 7 11	3 13 8
1777	Golden Gate	Previous to 1897	50 0 0	130 0 0	2 12 0		
3509	Golden Jubilee	1898	40 0 0				
98s	Golden Plum	Previous to 1897	85 0 0	2 0 0	0 0 11		

1559, 3541	Golden Queen	1897	5 5 0	16 10 0	3 2 20	66 0 0	4 0 0
	Do.	1898	288 0 0	146 19 21	0 9 20	561 14 2½	3 16 5
		Total	293 5 0	163 9 21	0 11 2	627 14 2½	3 16 8
1641, 1835	Golden Dyke (Tindal's Extended)	1897	18 0 0	2 5 0	0 2 12		
256s	Goulburn (Extended)	1898	47 6 0	27 11 5	0 11 10		
400	Great Coolgardie	Previous to 1897	10 0 0	12 0 0	1 4 0		
93s	Great Dyke and Orizaba Cement Claims ...	1897	3532 0 0	1110 6 0	0 6 6	4302 8 3	3 17 6
	Do.	1898	5 0 0	15 0 0	3 0 0	60 0 0	4 0 0
		Total	3537 0 0	1125 6 0	0 6 8		
3319	Great Hanover	1897	75 0 0	66 0 0	0 17 14		
	Do.	1898	110 0 0	44 1 0	0 8 0	170 13 10½	3 17 6
		Total	185 0 0	110 1 0	0 11 21		
442s	Great Junction	1898	114 0 0	134 19 0	1 3 16	519 10 9¾	3 16 11
132s	Great Scott	1897	67 0 0	314 14 9	4 13 22	1231 6 8¾	3 18 4
	Do.	1898	44 0 0	103 18 8	2 7 5	408 0 1	3 18 6
		Total	111 0 0	418 12 17	3 15 10	1609 6 9¾	3 18 4½
3647	Great Western	1898	24 0 0	16 19 0	0 14 3	66 10 6¾	3 18 6
3473	Gympie Jim	1897	87 12 0	99 15 22	0 19 8	361 15 2¼	3 12 6
89s	Hands Across the Sea United	1897	30 0 0	33 0 0	1 2 0		
61s, 62s	Hands Across the Sea G.M. Co.	Previous to 1897	45 0 0	34 0 0	0 15 2		
	Do.	1897	290 0 0	203 0 0	0 14 0		
	Do.	1898	980 0 0	765 1 3			
		Total	1315 0 0	1002 1 3	0 15 5		

Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold.		Value of Gold.	
				Total Yield.	Rate per ton.	Total Value.	Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
4835	Harp of Erin	1898	16 0 0	7 8 10	0 9 6		
1204	Herbert	1897	399 0 0	390 7 0	0 19 13		
	Do.	1898	245 0 0	255 0 6	1 0 19	892 10 10½	3 10 0
		Total	644 0 0	645 7 6	1 0 1		
3346	Herbert North	1897	9 0 0	16 1 12	1 15 17		
	Do.	1898	79 0 0	83 7 3	1 1 2	312 11 8½	3 15 0
		Total	88 0 0	99 8 15	1 2 14		
3629	Herbert South	1898	31 0 0	23 5 11	0 15 0	81 9 1¼	3 10 0
100s	Hilton	1897	2362 0 0	6836 0 0	2 17 21		
	Do.	1898	360 11 1	68 15 9	0 3 19		
		Total	2722 11 1	6904 15 9	2 10 16		
3607	Home Rule	1898	69 0 0	69 11 10	1 0 4		
3586	Hotspur South	1898	9 0 0	16 0 0	1 15 13½		
3456	Ida May	1898	10 0 0	18 18 0	1 17 19	73 11 0	3 17 10½
62s	Isa Muriel	1898	287 0 0	203 18 0	0 14 5	774 16 4¾	3 16 0
447s	John Bull	1898	10 0 0	136 16 18	13 13 16	526 3 11¾	3 16 11
462s	John Bull East	1898	45 0 0	95 14 0	2 2 12		

1491	Just in Time	1897	53 0 0	37 5 0	0 14 1		
	Do.	1898	182 0 0	64 10 0	0 7 2	241 8 9¼	3 14 8
		Total	235 0 0	101 15 0	0 8 15		
3280	Keep it Dark	1897	18 0 0	65 0 6	3 12 5		
405s	Kieora	1897	20 0 0	134 7 0	6 14 8	507 3 5	3 15 6
	Do.	1898	8 10 0	31 8 0	3 13 0	122 5 3¼	3 17 10½
		Total	28 10 0	165 15 0	5 15 0	629 8 8¼	3 16 1
3530	King's Cross	1897	52 0 0	50 16 0	0 19 13		
	Do.	1898	33 0 0	39 16 4	1 4 4		
		Total	85 0 0	90 12 4	1 1 8		
3536	King's Lynn	1897	10 0 0	14 17 0	1 9 16		
	Do.	1898	35 0 0	32 19 0	0 18 9	119 8 10½	3 12 6
		Total	45 0 0	47 16 0	1 1 5		
376, 18, 82, 8A, 3598	King Solomon	1897	593 0 0	1130 0 4	1 18 2	4181 0 7¼	3 14 0
	Do.	1898	407 0 0	454 4 6	1 3 3½	1739 15 6½	3 16 6
		Total	1000 0 0	1584 4 10	1 11 16	5920 16 1¾	3 14 8
269s.	Kinross	1898	24 0 0	24 9 0	1 0 9	85 11 6	3 10 0
359s.	Kintore North	1897	67 10 0	367 19 13	5 9 0	1439 14 2½	3 18 4
	Do.	1898	18 0 0	48 4 12	2 13 14	189 1 6¼	3 18 8
		Total	85 10 0	416 4 1	4 17 7	1628 15 8¾	3 18 4½

Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold.		Value of Gold.	
				Total Yield.	Rate per ton.	Total Value.	Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
1010, 1528, 2321	Ladas and Foston	Previous to 1897	6 0 0	2 8 0	0 8 0		
420s	Lady Alice	1897	28 0 0	23 10 0	0 16 18		
3552	Lady Bell	1898	50 17 0	21 12 0	0 8 6	81 0 0	3 15 0
532	Lady Emily	Previous to 1897	20 0 0	15 0 0	0 15 0		
414s.	Lady Elizabeth	1898	9 15 0	9 5 0	0 18 23	35 19 11½	3 17 10
3s.	Lady Evelyn	Previous to 1897	10 0 0	50 0 0	5 5 0		
	Do.	1898	618 18 0	693 4 20	1 2 9		
		Total	628 18 0	743 4 20	1 3 15		
2499	Lady Forrest Extended	1897	3 0 0	3 0 0	1 0 0		
1646	Lady Jeannie	1898	130 0 0	64 5 0	0 9 20½	248 19 4½	3 17 6
2010	Lady Forrest South	1897	195 0 0	585 0 0	3 0 0		
336, 284, 1583, 745, 2094, 2105, 2073	Lady Loch	Previous to 1897	1697 0 0	5260 0 0	3 1 23		
1763	Lady Mary	1897	50 0 0	15 6 0	0 6 2		
	Do.	1898	30 14 0	19 7 0	0 12 21	74 9 11¼	3 17 0
		Total	80 14 0	34 13 0	0 8 10		
2281	Lady Maud	Previous to 1897	14 0 0	11 15 0	0 16 18		

2160	Lady Robinson ...	1897	94 0 0	55 3 0	0 11 17	206 16 3	3 15 0
	Do. ...	1898	86 8 0	49 14 4	0 11 8	193 11 0¼	3 17 10½
		Total ...	180 8 0	104 17 4	0 11 12	400 7 3¼	3 16 4
756	La Mascotte ...	1897	50 0 0	21 11 0	0 8 14		
1840	Lefroy Gold Mines ...	Previous to 1897	100 0 0	10 0 0	0 2 0		
577	Lefroy Imperial ...	Previous to 1897	13 0 0	29 17 0	2 5 22		
47s	Lily ...	1898	259 15 0	197 3 12	0 14 17	764 0 2½	3 17 6
3556	Limerick ...	Previous to 1897	100 0 0	28 0 0	0 5 14		
446s	Life Boat ...	1898	33 0 0	13 2 0	0 7 22		
808, 2232	Lindsay's Gold Mines ...	1897	2842 0 0	1668 6 17	0 11 17	6674 6 10	4 0 0
	Do. ...	1898	1328 0 0	930 16 7	0 14 0	3721 1 4½	3 19 10½
		Total ...	4170 0 0	2599 3 0	0 12 11	10395 8 2½	3 19 11½
3297	Lindsay Gordon ...	1897	61 0 0	58 18 3	0 19 7		
	Do. ...	1898	63 0 0	26 18 0	0 8 12		
		Total ...	124 0 0	85 16 3	0 13 20		
2596, 2392	Little Blow and Golden Ridge Extended ...	1897	9 0 0	9 0 0	1 0 0		
1721	Lombard ...	Previous to 1897	25 0 0	28 17 0	1 3 1		
575	Londonderry ...	Previous to 1897	712 0 0	2379 0 0	3 6 10	8326 10 0	3 10 0
	Do. ...	1897	782 0 0	1204 13 0	1 11 14	42140 0 0	3 10 0
	Do. ...	1898	3563 0 0	4094 13 0	1 2 23	14962 1 4	3 12 11
		Total ...	5057 0 0	7678 6 0	1 10 8	65428 11 4	3 10 8½
1076	Londonderry South Block ...	Previous to 1897	20 0 0	40 0 0	2 0 0		

Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold. Total Yield.	Yield of Gold. Rate per ton.	Value of Gold. Total Value.	Value of Gold. Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
3531	Mammoth	1898	20 0 0	13 8 0	0 13 9½	46 18 0	3 10 0
471s	Matrix	1898	62 0 0	112 2 20	1 16 4		
22	McCulloch's	Previous to 1897	70 0 0	10 0 0	0 2 10		
1918	McKenzie's	Previous to 1897	329 0 0	468 4 0	1 8 10		
664, 1739	McPherson's Reward	1897	696 16 0	864 18 4	1 4 19	3304 12 7½	3 16 5
	Do.	1898	926 19 0	494 8 0	0 10 8	1872 8 0¼	3 15 11
		Total	1623 15 0	1359 6 4	0 16 10	5177 0 7¾	3 16 2
106s	Mexico	1897	731 0 0	1542 0 0	2 2 4	4626 0 0	3 0 0
	Do.	1898	729 10 0	1753 0 0	2 8 2		
		Total	1460 10 0	3295 0 0	2 5 3		
151s	Mexico Extended	1898	66 0 0	37 18 0	0 11 12	128 17 2¼	3 8 0
188A	Moon's Coolgardie	1898	92 0 0	32 13 3	0 7 2		
1902	Morning Star	1897	327 0 0	575 12 0	1 15 4		
2597	Mountain (Annatta)	1898	141 0 0	25 6 12	0 3 14	94 19 4½	3 15 0
2413	Mount Burgess	Previous to 1897	5293 0 0	5143 11 13	0 19 10½	20574 6 2	4 0 0
	Do.	1897	638 0 0	640 12 0	1 0 1½	2562 8 0	4 0 0
	Do.	1898	560 0 0	371 18 18	0 13 4	1473 14 3¼	3 19 3
		Total	6491 0 0	6156 2 7	0 18 23	24610 8 5¼	3 19 11½
1019	Mount Rowe Consolidated	Previous to 1897	16 0 0	13 0 0	0 16 6		
248s	Multum in Parvo	1897	55 0 0	68 16 0	1 5 0		

159s 1383	Mystery ... ... Nepean	1898 1898	33 0 0 26 0 0	38 10 23 10 0 0	1 3 8 0 7 8	149 17 2¼ 40 0 0	3 17 10½ 4 0 0
1093, 2292	New Australasian ... ... Do. ... ... Do.	Previous to 1897 1897 1898	20 0 0 2791 0 0 195 0 0	82 0 0 7157 0 0 1427 6 12	4 2 0 2 11 6 7 6 9	317 15 0 25776 0 0	3 17 6 3 10 0¼
		Total	3006 0 0	8666 6 12	2 17 15		
1405, 595	New Victoria Consols	Previous to 1897	105 0 0	59 0 0	0 11 6		
2638	New Victoria South ... ... Do. ... ... Do.	Previous to 1897 1897 1898	90 0 0 1222 0 0 987 0 0	150 4 0 1118 6 18 788 11 14	1 13 9 1 13 9 0 18 7	 574 10 3½ 4277 12 9¾	 3 16 6 3 16 6
		Total	2299 0 0	2057 2 8	0 16 8		
3484 1741, 1867	New Zealander ... ... No. 1 Worth Three Jolly Britons	1897 1897	10 0 0 20 0 0	2 13 0 9 7 0	0 5 7 0 9 8		
448s (2870)	Nil Desperandum	1898	10 0 0	5 0 0	0 10 0		
73s	Nordenfeldt ... ... Do.	1897 1898	231 10 0 408 0 0	374 15 0 411 18 15	1 12 7 1 0 4		
		Total	639 10 0	786 13 15	1 4 15		
1610 2413	North Burgess Gold Mine ... ... Do. ... ... Do.	Previous to 1897 1897 1898	101 0 0 102 0 0 783 0 0	75 0 0 703 12 0 1984 13 0	0 14 2 6 7 23 2 10 6		
		Total	986 0 0	2763 5 0	2 16 1		

Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed	Yield of Gold.		Value of Gold.	
				Total Yield.	Rate per ton.	Total Value.	Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
3252	Old Chum Extended	Previous to 1897	6 0 0	8 0 0	1 6 16		
105s	Ophelia	1897	1740 0 0	801 18 0	0 9 5	3207 12 0	4 0 0
	Do.	1898	334 3 3	246 2 11	0 14 17		
		Total	2074 3 3	1048 0 11	0 10 2		
317s	Ora Bunda	1897	120 0 0	165 15 19	1 7 15		
	Do.	1898	81 10 0	69 0 0	0 17 0		
		Total	201 10 0	234 15 19	1 3 8		
3481	Orchin	1898	478 0 0	129 0 0	0 5 9	503 2 0	3 18 0
77s	Ormuz	Previous to 1897	35 10 0	8 10 0	0 4 18		
	Do.	1898	2682 5 0	2353 12 0	0 17 13		
		Total	2717 15 0	2362 2 0	0 17 10		
99s	Orizaba	1898	Specimens	31 3 15			
337s	Pagoda	1897	25 0 0	5 0 0	0 4 0		
189s	Pantomime	1898	121 0 0	128 17 0	1 1 7		
427s	Palmer	1898	93 10 0	66 13 0	0 14 3	258 18 7¾	3 17 6
243s	Pearce's Find	Previous to 1898	10 0 0	60 0 0	6 0 0		
2s	Berry's Gold Reef	1897	120 10 0	228 10 0	1 18 2		
2434	Perseverance Extended	1897	55 0 0	6 0 0	0 2 4		
1903	Phœnix...	1897	53 0 0	26 10 0	0 10 0		
3613	Pilgrim	1898	10 0 0	10 9 0	1 0 22	39 3 9	3 15 0
113s	Platypus	1898	201 0 0	240 6 4	1 3 21	903 1 6	3 15 1

79s	Premier	Previous to 1897	3141 0 0	6308 15 12	2 0 19	24131 1 3¼	3 16 6
	Do.	1897	4358 0 0	4901 3 6	1 2 11	18746 8 10¾	3 16 6
	Do.	1898	9085 0 0	5863 7 19	0 12 21	22405 17 4½	3 16 11
		Total	16584 0 0	17073 6 13	1 0 14	65283 7 6½	3 16 7¾
74s	Premier South	1897	69 0 0	126 2 0	1 16 13		
	Do.	1898	813 0 0	268 19 6	0 6 14		
		Total	882 0 0	395 1 6	0 8 23		
369s	Pride of the Jaurdies	1897	44 0 0	100 0 0	2 5 10	387 10 0	3 17 6
	Princess Midas...	1898	19 0 0	14 19 0	0 15 17		
3417	Queenslander	1898	141 6 3	696 14 5	4 18 0		
3573 3609 1019	Queensland Coolgardie (Richmond)	1898	218 10 1	270 3 8	1 4 17		
3623	Queen of Sheba	1898	25 0 0	5 4 20	0 4 4	19 0 0	3 12 6
1728	Queen's Reign	1898	2 0 0	0 17 0	0 8 12		
	Quartz Claim	1898	12 0 0	38 4 0	3 3 16	144 10 5¾	3 15 8
2077	Ramage Syndicate	1897	4 12 0	6 9 0	1 8 1		
1728	Red Jacket	Previous to 1897	2 0 0	3 0 0	1 10 0		
3648	Rising Sun (Coolgardie)	1898	0 4 0	15 0 0	75 0 0	54 7 6	3 12 6
441s	Rising Sun (Kunanalling)	1898	13 0 0	13 0 8	1 0 0½	47 3 8½	3 12 6
45s	Royal Sovereign	Previous to 1897	2 0 0	30 0 0	15 0 0		
	Do.	1897					
	Do.	1898	90 0 0	196 7 12	2 3 15	787 18 6¾	4 0 1
		Total	92 0 0	226 7 12	2 9 5		
226	Rose Hill United	1898	364 0 0	185 1 20	0 10 4	694 1 10½	3 15 0
1839	Royal Tar	1897	50 0 0	2 11 15	0 1 0	9 7 1½	3 12 6
	Do.	1898	72 5 0	36 13 3	0 9 10½	132 17 6¾	3 12 6
		Total	122 5 0	39 4 18	0 6 9	142 4 8½	3 12 6

Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold. Total Yield.	Yield of Gold. Rate per ton.	Value of Gold. Total Value.	Value of Gold. Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
1383	Sam's Wealth of Nations ...	1897	47 0 0	10 0 0	0 4 16	182 2 6	3 17 6
	Do. ...	1898	26 0 0	10 0 0	0 7 16		
		Total ...	73 0 0	20 0 0	0 5 11		
3426	St. Mildred ...	1898	386 0 3	1201 14 8	3 2 6	4263 8 0¼	3 10 10
3578	Saint George ...	1898	61 0 0	89 10 0	1 9 8		
3416, 3415, 3510	Sherlaw's Perseverance ...	Previous to 1897	216 0 0	444 0 0	2 1 2	1515 3 0	3 8 3
		1897	1895 0 0	718 10 12	0 7 13	2451 4 3¾	3 8 3
		1898	2641 0 0	1853 9 0	0 14 0	6314 13 6¼	3 8 1
		Total ...	4752 0 0	3015 19 12	0 12 16	10281 0 10½	3 8 2
3562	Smith's Find ...	1898	21 0 0	80 8 0	3 16 3½	301 4 3¾	3 17 1⅓
376s	Stanley ...	1897	23 0 0	11 0 0	0 9 13		
73	Star of the South ...	1897	150 0 0	270 0 0	1 1 14		
2725	Steadman's Choice ...	1898	19 19 0	9 10 7	0 9 13	36 17 4½	3 17 6
409s	Sugar Loaf ...	1897	146 0 0	746 12 0	5 10 22		
	Do. ...	1898	107 10 0	286 15 0	2 13 5		
		Total ...	253 10 0	1033 7 0	4 1 12		
3520	Telluride King ...	1898	25 0 0	30 17 20	1 4 17		
1835	Tindal's Central ...	1898	156 0 0	65 13 10	0 8 10		

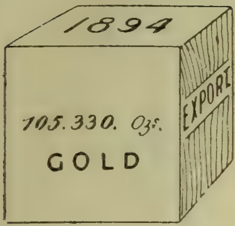
33	Tindal's Coolgardie	1897	550 0 0	246 19 0	0 8 25		
	Do.	1898	4044 0 0	1065 0 14	0 5 $6\frac{1}{4}$	3940 0 $8\frac{3}{4}$	3 10 11
		Total	4594 0 0	1311 19 14	0 5 17		
3561	Tindal's Consols	1897	19 16 0	11 8 0	0 11 12	42 9 $3\frac{1}{2}$	3 14 6
	Do.	1898	172 0 0	42 17 10	0 4 23	156 1 $2\frac{1}{4}$	3 12 6
		Total	191 16 0	54 5 10	0 5 15	198 10 $5\frac{3}{4}$	3 12 $11\frac{3}{4}$
94s.	Trident	Previous to 1897	100 0 0	32 0 0	0 6 9		
1385	Union Jack	1897	300 0 0	340 15 0	1 2 17	1235 4 $4\frac{1}{2}$	3 12 6
	Do.	1898	177 10 0	181 14 18	1 0 9	681 3 $10\frac{1}{4}$	3 14 11
		Total	477 10 0	522 9 18	1 1 21	1916 8 $2\frac{3}{4}$	3 13 4
130, 215, 436, 1145	United Gold Reefs	Previous to 1897	29 0 0	10 0 0	0 6 21		
	Do.	1897	4 0 0	7 0 0	1 15 0		
		Total	33 0 0	17 0 0	0 10 7		
3587	United Brothers	1898	56 0 0	32 1 0	0 11 10		
1552	Vale of Coolgardie	Previous to 1897	166 0 0	127 0 0	0 15 7	492 2 6	3 17 6
	Do.	1897	2476 0 0	3379 3 22	1 7 7	13094 7 $7\frac{3}{4}$	3 17 6
	Do.	1898	2165 0 0	1527 14 6	0 14 2	5919 17 $2\frac{1}{4}$	3 17 6
		Total	4807 0 0	5033 18 2	1 0 22	19506 7 $4\frac{1}{4}$	3 17 6
3616	Valentine	1898	17 10 0	18 10 0	1 0 15		
225s	Victor	1897	24 0 0	9 7 0	0 7 19	36 4 $7\frac{1}{2}$	3 17 6
	Do.	1898	74 3 0	279 2 12	3 15 6	1122 10 $7\frac{1}{4}$	4 0 4
		Total	98 3 0	288 9 12	2 18 20	1158 15 $2\frac{3}{4}$	4 0 3

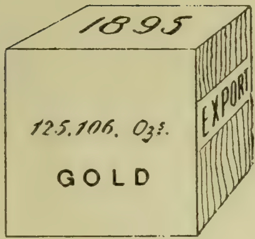
Return showing the Yield of the Leases on the Coolgardie Goldfield—continued.

Number of Lease.	Name of Lease.	Date.	Quantity of Stone Crushed.	Yield of Gold. Total Yield.	Yield of Gold. Rate per ton.	Value of Gold. Total Value.	Value of Gold. Rate per oz.
			tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	£ s. d.	£ s. d.
3663	Victoria Cross	1898	11 1 0	2 6 0	0 4 4½	8 6 9	3 12 6
16s	Vincent	1897	74 10 0	44 15 0	0 12 0		
124s	Waverley	1897	20 0 0	30 7 0	1 10 8		
	Do.	1898	195 16 0	375 19 12	1 18 7	1499 5 1½	3 19 8¾
		Total	215 16 0	406 6 12	1 17 7		
1151	Westralia Extended	1898	10405 9 0	4312 8 19	0 8 6	15840 10 11½	3 13 5
144	Westralia	1898	6013 14 0	2937 17 2	0 9 18	10771 5 10	3 13 3¾
1639	Westralia East Extension	Previous to 1897	232 0 0	106 0 0	0 8 3	393 1 8	3 14 2
144, 1151	Do.	1897	7555 2 0	8183 15 6	1 0 5	30348 2 4½	3 14 2
2146	Do.	1898	16697 11 0	10317 1 21	0 12 8	38302 4 2¼	3 14 2
		Total	24484 13 0	18606 17 3	0 15 4	69043 8 2¾	3 14 2
308s	Westralia Premier	1897	Specimens	17 6 12			
17s	Wealth of Nations	1898	7715 0 0	4545 18 6	0 11 15	17194 6 8¼	3 15 7
378s	Zealandia	1897	25 0 0	5 0 0	0 4 0		
383s	Zulieka	1898	318 0 0	408 5 0	1 5 16		
382s	Zulieka North	1897	26 0 0	38 14 0	1 9 18		
		GRAND TOTAL ...	206211 13 1	242235 14 16	1 3 11		

TORRINGTON BLATCHFORD,
Assistant Geologist.

By Authority: RICHARD PETHER, Government Printer, Perth.

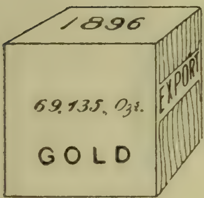


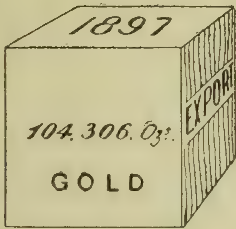


DIAGRAM

SHEWING YEARLY EXPORT OF GOLD

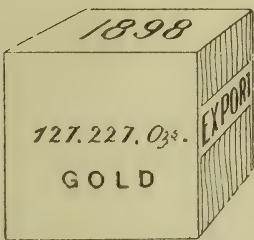
FROM





THE COOLGARDIE GOLD FIELD

SINCE 1894.



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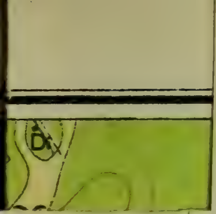

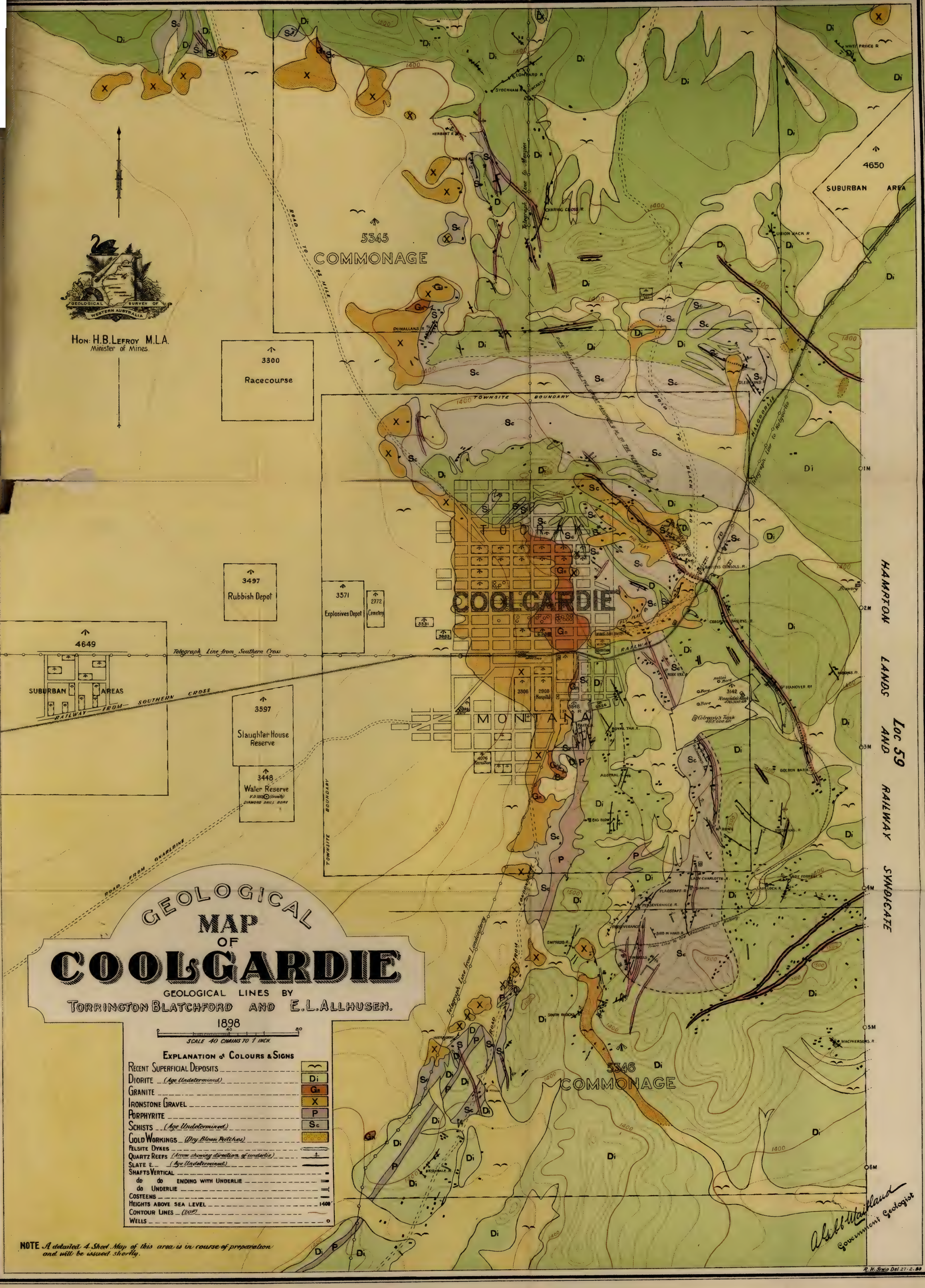
GEOLOGICAL MAP OF COOLGARDIE
GEOLOGICAL LINES BY
TORRINGTON BLATCHFORD AND E. L. ALLHUSEN.
1898
SCALE 40 CHAINS TO 1 INCH.
EXPLANATION of COLOURS & SIGNS
RECENT SUPERFICIAL DEPOSITS
DIORITE (Age Undetermined) Di
GRANITE Gn
IRONSTONE GRAVEL X
PORPHYRITE P
SCHISTS (Age Undetermined) Sc
GOLD WORKINGS (Dry Blown Patches)
FELSITE DYKES
QUARTZ REEFS (Arrow showing direction of underlie)
SLATE (Age Undetermined)
SHAFTS VERTICAL
do do ENDING WITH UNDERLIE
do UNDERLIE
COSTEENS
HEIGHTS ABOVE SEA LEVEL 1400
CONTOUR LINES (20ft)
WELLS
NOTE A detailed 4 Sheet Map of this area is in course of preparation and will be issued shortly.
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
HON: H.B. LEFROY M.L.A. Minister of Mines.
5345 COMMONAGE
3300 Racecourse
3497 Rubbish Depot
3571 Explosives Depot
2772 Cemetery
4649 SUBURBAN AREAS
3597 Slaughter House Reserve
3448 Water Reserve
4650 SUBURBAN AREA
5346 COMMONAGE
COOLGARDIE
TOORAK
MONTANA
TOWNSITE BOUNDARY
Telegraph Line from Southern Cross
RAILWAY FROM SOUTHERN CROSS
ROAD TO 25 MILE
ROAD FROM GNARLBINE
HAMPTON LANDS AND RAILWAY SYNDICATE Loc 59
A. Gibb Maitland Government Geologist

1900.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 4.

THE MINERAL WEALTH

OF

WESTERN AUSTRALIA,

BY

A. GIBB MAITLAND, F.G.S.,

GOVERNMENT GEOLOGIST.

Issued under the authority of the Hon. H. B. Lefroy, M.L.A., Minister of Mines.

PRELIMINARY ISSUE.

PERTH:

BY AUTHORITY: RICHARD PETHER, GOVERNMENT PRINTER.

1900.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA.

LIST OF OFFICERS.

Government Geologist	...	A. Gibb Maitland.

Field Staff:

Assistant Geologist ...	...	Torrington Blatchford, B.A., F.G.S.
Topographical Surveyor	...	W. D. Campbell, A.M.I.C.E., L.S., F.G.S.
Field Assistant ...	...	J. H. Brooking.

Laboratory Officials:

Mineralogist and Assayer	...	E. S. Simpson, B.E., F.C.S.
Laboratory Assistant	...	C. C. Williams.
Cadet	...	H. Bowley.

Office Staff:

Draftsman... ...	...	R. H. Irwin.
Clerk and Accountant	...	F. J. Kelly.
Messenger	...	G. O. Bailey.

TABLE OF CONTENTS.

PREFATORY NOTE.

THE Mining Handbook written by my predecessor having been for a long time out of print, it has been deemed necessary, owing to the growing demand for some concise official information with reference to the Mineral Resources of the Colony, to issue a new edition.

After careful consideration, it was found better to prepare practically a new work, which would embody all the latest official information as to the Mineral Resources of Western Australia.

Owing to the vast area of the Colony, and the exigencies of travel, it has not been possible for me, as yet, to examine even in a most cursory manner all portions of Western Australia, hence the information with reference to certain districts—more especially that promising area between the Gascoyne and the DeGrey Rivers—is not so ample as could be wished.

The pamphlet is accompanied by a series of plans illustrating the geology of certain of the mineral fields, and a coloured map showing the distribution of the useful minerals, together with the location of the different goldfields and mining districts.

The statistics, as to the Mineral Production of the Colony—without which the pamphlet would have been incomplete—have been taken from official sources.

In addition to the work of the Geological Survey, I have freely availed myself (with due acknowledgment) of the labours of my predecessors, as well as the other unofficial observers, by whose researches our knowledge has been materially increased.

A compilation of this nature affords little scope for originality, but an attempt has been made to present a faithful account of the Mineral Wealth of the Colony, and to indicate those localities awaiting the attention of all classes of the mining community; it is for others to judge how far this has been accomplished.

A. GIBB MAITLAND,

Government Geologist.

Geological Survey Office, 22nd January, 1900.

CHAPTER I.

The Salient Geological Features of Western Australia.

INTRODUCTION, ARCHÆAN, CAMBRIAN, SILURIAN, DEVONIAN, CARBONIFEROUS, MESOZOIC, CAINOZOIC, VOLCANIC ROCKS.

INTRODUCTION.

The Mineral Resources of a country being so intimately associated with its geology, it is natural that any account of the former should be dealt with only after its geological features have been properly understood. This account of the salient geological features of Western Australia must, however, be regarded more in the light of a statement of the present condition of our knowledge than a detailed memoir thereon, and should serve to show how much has yet to be learnt on the subject.

Certain very small portions of the Colony which are of economic importance have in late years received somewhat detailed investigation, but there are many portions which are as yet only imperfectly known, while by far the larger area of the Colony has never yet been examined by any trained geologist, and many years must elapse before even the dominant geological features can be grasped.

In the compilation of this account I have freely availed myself of the work of my predecessors and of those other scientists to whom Western Australian Geologists owe a debt of gratitude. As this article is to a large extent based upon the labours of previous official geologists, it is not out of place to give a succinct account of their observations.

Dr. F. von Sommer would appear to have been the first official geologist employed in the Colony. This gentleman travelled extensively during the years 1847 to 1857 throughout the Colony. He geologically examined the Victoria, Toodyay, and York Districts, and extended his observations to the country lying between the latter and Mt. Barren, on the South Coast. Neither the maps nor reports of this worker have ever been published, although three articles from his pen bearing upon the geology of the Colony have appeared in the pages of current literature during the years 1848 and 1849.*

* *Vide* "Bibliography of the Geology of Western Australia." A. Gibb Maitland, Perth: By Authority, 1898.

After an interval of 21 years, during which much excellent geological work was accomplished by the Gregory Brothers, H. Y. L. Brown was appointed to the post of Government Geologist. This officer, during the years 1870-71, prepared three geological maps and issued ten reports (now out of print), all of which have been laid under contribution in the preparation of this *résumé*.

In 1882 E. T. Hardman, of the Geological Survey of Ireland, was appointed Government Geologist. His labours were chiefly confined to the Kimberley District, upon which he issued two voluminous reports illustrated with a series of maps and plates. Mr. Hardman's researches laid the foundations of our knowledge of the geology of the Northern portion of the Colony, and also led to the discovery of the Kimberley goldfield. This officer examined the neighbourhood of Bunbury, Blackwood, etc., and investigated the vicinity of Perth with reference to the question of its water supply from subterranean sources.

The late Rev. C. G. Nicolay contributed largely to our knowledge of the geology of the Colony, and was the founder of the Geological Museum in Fremantle, now merged into the Perth Museum.

In 1887 H. P. Woodward was selected to fill the post of Government Geologist. Mr. Woodward, in the course of his official duties (1887-1895), travelled over the length and breadth of the Colony and, with a small appropriation, published 21 voluminous reports and six geological maps.

Archæan Rocks.

The oldest formation in Western Australia is that comprising those gneissic, granitoid, and schistose rocks, which cover such an enormous area of the country, and form the floor upon which the newer strata have been laid down. To the whole of these metamorphic rocks observers have invariably assigned an Archæan Age; this, however, is more inferred than proved. There is only one instance on record, at the present time, upon which this classification may be considered to have been determined by palæontological evidence.

In the Kimberley District certain limestones, sandstones, quartzites, etc., have yielded Lower Cambrian fossils, viz. *Salterella Hardmani* and *Olenellus* (?) *Forresti*. These fossiliferous beds are considered, and may probably be, newer than the gneissic and schistose rocks in the vicinity. So far as observations have at present been carried, no actual junction has been noticed between the schists and the fossiliferous strata, and there is nothing already in the evidence available incompatible with the supposition that the talcose and mica schists and other associated rocks represent much more highly metamorphosed portions of the Lower Cambrian Beds.

In the absence of direct stratigraphical or palæontological evidence, it is convenient for descriptive purposes to adhere to a purely lithological classification, and to separate the gneissic, granitoid, and schistose rocks from those in which metamorphism has not been carried sufficiently far to entirely obliterate their clastic character.

These Archæan rocks have been thus described by H. P. Woodward, formerly Government Geologist:—

This great group of rocks are more largely developed in this Colony than in any other portion of the world, outcropping as they do in all parts of the country, and where they are overlain by more modern formations these latter are rarely of any great thickness. This series is highly contorted, being folded into a number of parallel anticlinal and synclinal folds, striking North and South, and often presenting the appearance of a highly inclined dip, which is either nearly vertical or trending to the Eastward. These rocks are much broken and faulted by numerous diorite and granite dykes; they contain many quartz veins and iron lodes, and it is in this group of rocks that the principal auriferous deposits exist. This great series of rocks may be subdivided into three sections—the granites, the gneisses, and the schists, which, as a rule, run in parallel belts North and South, with a slight trend to the North-West.

The first, or Western belt, extends from the Murchison River to the South Coast, but is very little exposed, except in the Northampton District, and a little South of the Irwin River, where it is rich in copper, lead, and zinc lodes. It underlies the sandy coastal plains, outcropping here and there at the base of the Darling Range, forming a small range between the Capes Naturaliste and Leeuwin, and characterised throughout by lead, copper, and zinc lodes. The rocks of this belt are, for the most part, comparatively soft, consisting of clay-slates (often kaolinised), quartzites, and schists, with dykes of diorite and granite, and veins of quartz, containing lead, copper, zinc, iron pyrites, and ferruginous graphite.

The second belt extends Northward from the South Coast (forming the bold escarpment at the edge of the great plateau called the Darling Range) as far as the Murchison River. It then follows this river in a narrow belt in a North-Easterly direction for about 200 miles, where it suddenly spreads out to the East and North-West from the Robinson Range to the Lyons River, disappearing beneath the magnesian limestones to the Northward. In this belt the rocks are mostly hard and crystalline, consisting principally of gneiss and schist, with dykes of diorite, granite and felstone, and veins of quartz. The latter (as well as the diorite) often contains large quantities of pyrites, most of which yield a little gold. Tin is also being worked at the Greenbushes Tinfield, the ore being derived from the disintegration of quartz-porphyry dykes, in which it is associated with tourmaline and titanic iron. Besides iron and manganese, large deposits of kaolin of a very fine quality occur, as well as veins containing mica and asbestos; but these latter are too much weathered at their outcrop to be of any value. Near Bridgetown a very large deposit of graphite has lately been opened up; it exists in the form of a bed between talcose schists, about 20 feet in thickness.

The third, or great granite belt, lies about 100 miles East from the West Coast, and is about 100 miles in width, extending from the South Coast to the Murchison River. It consists of a series of bold, bare outcrops of gneiss or granite, often 100 feet in height, and covering several hundred acres in extent, rising from loamy flats. The rocks mostly outcrop in the depressions of the table-land, the higher portions of which are covered by sand plains. This belt is absolutely destitute of mineral veins, and it is due to this barrier that the rich goldfields to the Eastward remained so long unprospected. These outcrops are made use of for the conservation of water in

this dry portion of the Colony, as they shed water like a house-roof, whilst around them there are many natural dams or basins filled with sand, which are either being cleaned out or wells are being sunk in them. The rocks of this belt consist entirely of gneiss and granite, much fissured and faulted, and traversed by numerous dykes of granite and diorite, whilst the main masses generally enclose fragments and masses of schistose and gneissic rock.

The fourth, or *first auriferous belt*, is situated immediately to the Eastward of the granite belt, and is about 20 miles in width. It starts from the South Coast at the Phillip's River, extending Northward in a narrow belt by the Ravensthorpe Range, Parker's Range, Southern Cross, Golden Valley, Mt. Jackson, Mt. Kenneth, Mt. Magnet, Austin's Lake to Cue. Thence it takes a slight bend to the North-East to Nannine and the Star of the East, where it strikes more to the North, and skirting round the heads of the Murchison and Gascoyne Rivers, it turns North-West and follows down the Ashburton Valley to its junction with the Henry, finally disappearing beneath the Palæozoic formation. The rocks of this belt consist mostly of hornblende, mica, or talc schists, of which the hornblende schists so closely resemble diorite that it is impossible to distinguish it in a broken specimen. The rocks of this belt are a good deal broken and faulted by granite and diorite dykes, and quartz lodes containing gold, iron and copper. There are also some large magnesia lode-masses, rich in fine gold, which will probably prove to be serpentine at a depth. Many of the lodes also contain large quantities of chlorite.

The fifth, or second granite belt is about the same width, and similar in every way to the first mentioned. It extends from the South Coast, following the line of the first auriferous belt North, and, like it, dipping under the Palæozoic tableland of the Fortescue. Only a small portion makes its appearance on the Northern side of the Yule River, near Pilbarra, upon the North-West Coast.

The sixth, or *second auriferous belt*, lies next, and at present its width is unknown, but it is certainly of considerable width in places, and has proved, wherever prospected, to be extremely rich in gold. It extends North from the Dundas Hills (where this formation first outcrops from below the sand plains) by Wagemulla,* Coolgardie, and Three Pinnacles, Ularring, Lake Carey, and following about the same line as the other belts, and turning with them to the North-West by the Nullagine, Marble Bar, Pilbarra, Egina, and Mallina upon the North-West Coast. The rocks of this belt are generally very similar to those of the first auriferous belt, but the formation and lodes are a great deal more faulted and broken; however, to make up for this, they are the richest that have ever been discovered.

The hornblende rocks of this Colony are very remarkable in character, being met with most abundantly from North to South. They vary immensely in colour, structure, and external character, some at first glance having the appearance of clay-slate, but on being fractured they exhibit a structure similar to diorite, whilst others again only contain green crystals of hornblende disseminated through a quartz matrix, or have a jade-like appearance, which latter variety are continually being mistaken for copper, nickel, or silver. With these rocks are associated the principal mineral deposits of the Colony—gold, tin, copper, antimony, lead, zinc, manganese, and iron.

The spur of which Magpie Hill, in the Porongorup Range to the North of Albany, forms the highest summit, trends generally North-West and South-East, which is practically coincident with that of the foliation of the granitic gneiss; but what is of signifi-

* (?) Widgiemooltha.

cance is that the trend of the foliation has determined that of the longer axes of the felspar crystals.

In the Pilbarra Goldfield there are distinct traces of a double foliation in the gneiss, which is particularly well seen in the bed of the Big Sherlock River, where it is crossed by the road to Mallina. The older and coarser banding has a North and South strike at the Big Sherlock section, and at right angles to this are zones of secondary and much finer foliation, within which it has the character of a mylonite or a fine quartz schist, perfectly distinct from the original rock.*

Cambrian Rocks.

An undoubted Cambrian fauna has been discovered in the rocks of the Kimberley District. The fossils consist of *Salterella Hardmani* and *Olenellus (?) Forresti*, and are associated with certain limestones, sandstones, quartzites, clay slates, and sandy flags. Very little is known of these Cambrian Rocks at present; their superficial area, however, would seem to be extensive, for they have already been proved to extend in a North-East and South-West direction from the Burt Range and for some distance to the Southward of Mount Dockrell. No estimate has yet been made of the thickness of these the oldest fossiliferous beds yet found in the Colony. The strata have been tilted in such a way that the principal axes of folding is North-West and South-East.

The Cambrian Rocks of Kimberley are of considerable economic importance, in that they form the matrices of those auriferous quartz reefs which have already been exploited. As can be seen by reference to a later page, a fairly large quantity of gold has been returned from this district. Although the figures include a considerable quantity of alluvial gold, it is a natural assumption that this was originally derived from the disintegration of the Cambrian beds.

Silurian Rocks.

The occurrence of Silurian Rocks in Western Australia has been more inferred than proved.

Writing in 1861, F. J. Gregory described certain rocks of the Mount Barren Range as being probably of Silurian Age, though the evidence upon which this deduction is based was not given.

The rocks of the Stirling Range, which lies about 50 miles North of Albany, have been claimed as Silurian. The beds consist of quartzites, sandstones, and shales, the whole being traversed by quartz veins. The beds are highly folded, contorted, and faulted in places. According to the researches of H. P. Woodward, the rocks at the Western end of the Range, near Mondinup, have been thrown into three sharp anticlinal and synclinal folds, in a distance North and South of about 10 miles, by a lateral compression from the South.

* The Geological Features of the Coast of Western Australia. H. M. Cadell, Trans. Geol. Soc., Edin., 1896.

This series of rocks, although covering a considerable area, are plicated in such a manner that two or three beds form the entire range, rising abruptly from beneath the plain to the Northward, and dipping under it again to the Southward . . . . *

The strata chiefly developed in the Leopold and Mueller Ranges of Kimberley, have been provisionally classed as Silurian, more, however, on account of their lithological character than on any stratigraphical or palæontological evidence.

The rocks composing the Leopold and Mueller Ranges are of various textures. They are sometimes pure crystalline quartzites, and sometimes fine grained but highly indurated grits, having an almost vitrified appearance. Coarse pea-grits, and quartzose conglomerates are everywhere met with, but as a rule the whole mass shows indication of extreme metamorphic action. Interbedded with these however, we meet with beds of soft sandstones, and purple slates, which have apparently suffered no alteration whatever.†

Much detailed fieldwork is, however, required before the occurrence of undoubted Silurian Rocks in Western Australia can be considered to have been definitely proved.

Devonian Rocks.

The Devonian Rocks of Kimberley have been described by E. T. Hardman as consisting of hard grits, conglomerates, indurated limestones and shales. They are seen to rest unconformably upon a series of schists and slates which have been claimed as being of Lower Silurian Age; they are covered by basaltic lavas which are in turn partly overlaid by undoubted Carboniferous Rocks. The Devonian Strata occupy an area of about 2,000 square miles, and calculations have shown that their thickness is about 10,000 feet.

The Kimberley Devonian Rocks have yielded the following fossils:—*Actinostroma clathratum, Stromatoporella Eifeliensis, Pacypora tumida, Cyathophyllum virgatum, Cyathophyllum depressum, Aulopora repens, Spirorbis omphaloides, Spirifera, Atrypa reticularis, Rhynchonella pugnus, Rhynchonella cuboides, Orthoceras, and Goniatites.*

Associated with these sedimentary beds are contemporaneous basalts, dolerites, anamesites, volcanic breccias and ashes. These volcanic rocks extend over a large area of country, and also attain a considerable thickness, having been estimated to reach from 1,000 to 1,100 feet. No undoubted volcanic focii have been observed in the district over which these lavas extend, though certain peaks and cones have been mentioned by Mr. Hardman as being likely to prove on detailed examination to be ancient volcanic vents.

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* The Country between Broomehill and the Dundas Hills, and the Mines in that neighbourhood. H. P. Woodward. *Ad interim* Report on the Department of Mines for the half-year ending 30th June, 1894. Perth: By Authority: 1894; p. 14.

† On the Geology of the Kimberley District. E. T. Hardman, Perth: By Authority: 1885; p. 23.

Carboniferous Rocks.

The Carboniferous Rocks of Western Australia cover a very large area of country and seem to be particularly well developed in the Kimberley District. The formation is divided into an Upper or Sandy, and a Lower or Calcareous Series.

The occurrence of the Carboniferous formation would seem to have first been published by Sir George (then Lieut.) Grey in the year 1841, in his journals of Two Expeditions of Discovery in North-West and Western Australia during the years 1837-39. Dr. F. Von Sommer, the first Government Geologist of the Colony, traced the Carboniferous Beds, in 1848, from the heads of the Irwin River to those of the Moore, for a distance of about 160 miles.

There are three distinct districts in which fossiliferous Carboniferous Rocks are known in the Colony, viz., Kimberley, the Gascoyne, and the Irwin River District.

The Kimberley Beds.—The Carboniferous Rocks of Kimberley are represented by wide-spread deposits of sandstones, grits and conglomerates, all containing bands and nodules of hematite or ironstone, as well as magnesian and other limestones.

The Upper or Sandy Series, according to E. T. Hardman* by whom these beds were first described :—

Extends from Roebuck Bay, on the West, to the Napier and Oscar Ranges on the East, and is recognised alike on the North side of Stokes Bay, and in the St. George Ranges 100 miles to the South . . . . . It may reasonably be asserted that this Sandstone formation is considerably over 1,000 feet in thickness, for the Grant Ranges have an elevation of over 900 feet above the plain, while the nearest limestone is 60 or 70 miles distant; and probably its continuation lies (even assuming a moderate angle by dips) many hundreds of feet below the Sandstones of the Grant Range and Mount Anderson. The sandstones here dip at high angles, so that the thickness of strata is considerably more than the actual height of the hills above the plain. . . . . Besides those on the Fitzroy it occupies a considerable portion of the Haughton Ranges, which extend for some 35 or 40 miles. It is next seen in the Ord District, along the North-West of which it stretches for over 50 miles in length, with a minimum width of about 20. Here it rises into high ranges, of which Dixon Range and the Hills marked J39 are prominent examples. Hardman Range, to the South, is also composed of it. Further North the strip of country extending from Mount Elder along the Negri to the South of Mount Panton is mainly composed of this formation, although occasionally subordinate bands of limestones are met with in these rocks.

Of the Carboniferous Limestone (Lower) Series the same author writes :—

This formation extends in a wavy line from Alexander Creek through the Napier Range, Oscar Range, Geikie Range, etc., from North-West to South-East, as far as the Margaret River, ending within a few miles of the Leopold Range. In this direction it is at its widest, as its breadth may be estimated from the various outcrops and ranges above the plains at 30 miles. It gradually narrows northwards, and at Napier Range is not more than seven miles wide; this includes the portion hidden beneath alluvium, etc.; but the limestone comprising the range itself is not more than two

* The Geology of the Kimberley District, Western Australia. Perth: By Authority: 1885.

miles in width. The general character of the limestone is the same throughout. It is light-coloured, compact, brittle, splintery, more or less magnesian limestone. In colour it varies from light grey to flesh colour, and sometimes pink. For the most part it is massively bedded, and it is not always easy to discern the direction of the bedding, as it is cut through by numerous joint lines, and often coated with stalagmite. The general appearance it presents is that of a very rugged vertically bedded rock, in consequence of these joints; the summits of the ranges being worn into points, pinnacles, and other fantastic shapes. On examination, however, it is seen that the rock dips at a very moderate angle, varying from 5° to 25°, the direction of the dip being usually at right angles to the trend of the hills. The limestone is interbedded with many thick layers of shale and thin arenaceous limestone; but these only occur in the lower beds, at the base of the hills.

Further to the East the Carboniferous Limestone appears in great force in the Rough Range, and extends to the South-East towards Haughton Range, a distance of nearly 30 miles. The extent of the limestone laterally, that is to the South-West, is not known, but in many places it is seen for 6 or 8 miles, and South-West of Mount Huxley it stretches from its Eastern edge, near J8, for nearly 20 miles in that direction. The limestone crops up at intervals between this range and Mount Pierre to the northwards, and is seen in various parts of the River Margaret, extending in rather high hills on the North of that river, both to the East and West (Hull Range, Mount Krauss, etc.).

The Carboniferous Limestone Series of the localities above described:—

Consist in great part of rather massively bedded light grey and sometimes flesh coloured limestone, often magnesian, but interbedded with thin, flaggy, earthy, and sometimes sandy limestone. But these chiefly occur among the lower beds, and are often interstratified with dark grey sandy shales. The valley of the Margaret is mainly composed of thin, flaggy, hard limestone (which gives a bell-like sound when struck with the hammer), earthy fetid limestones and shales with nodular limestone bands.

From the last mentioned locality no Carboniferous Limestone makes its appearance for a distance of about 120 miles.

A short way below the junction of the Panton and Elvire Rivers limestone again makes its appearance, and occupies a wide area extending as far North-Easterly as for several miles beyond the Negri, in all about 75 miles; while in width it averages from 20 to 30 miles. This portion of the limestone country rises in a succession of low and almost imperceptible terraces into high tablelands. One of these extends to the East of the Ord near the cattle station, and another to the North and East of the Negri River where it is capped by Mount Panton. The Ord limestones are for the greater part hard and flaggy, rarely massive, usually grey in colour, sometimes sandy or magnesian, and seldom fossiliferous. In many parts of the district they are interbedded with red shales, marls, and sandstones, the former of which contain occasionally layers of gypsum together with traces of rock salt.

The Carboniferous beds of Kimberley have yielded the following fossils:—*Lepidodendron*, sp.; *Stigmaria*, sp.; *Stromatopora concentrica* (?) *Stromatopora placenta*, sp.; *Pachypora tumida*; *Zaphrentis*, sp.; *Syringopora*, sp.; *Actinocrinus*, sp.; *Platycrinus*, sp.; *Poteriocrinus crassus*, Miller; *Pentremites*, sp.; *Serpula: Spirobis*, sp.; *Fenestella plebeia (antiqua)*, M'Coy; *Productus, giganteous*; *Productus longispinus*; *Productus semireticulatus*; *Chonetes*, sp.; *Chonetes Hardrensis*; *Discina*; *Orthis resupinata*;

Strophalosia Clarkei, Eth. fils ; *Rhynchonella pugnus* ; *Rhynchonella pleurodon* ; *Rhynchonella cuboides* ; *Orthotetes crenistria*, Phillips ; *Streptorhynchus crenistria* ; *Terebratula hastata* (?) ; *Terebratula sacculus* (?) ; *Pleurotomaria*, sp. ; *Toxonema*, small sp. ; *Natica*, sp. ; *Ceriopora*, sp. ; *Chaetetes tumidus* ; *Stenopora Tasmaniensis* ; *Cyathophyllum*, sp. ; *Cycthophyllum virgatum* ; *Cyathophyllum depressum* ; *Lithodendron affine*.

The Gascoyne Beds.—The strata of the Gascoyne River consist of a series of crystalline limestones, full of corals, dipping at an angle of about 10 degrees to the Westward. Beneath these are shales, which yield Lower Carboniferous fossils. At the base of the series is a boulder conglomerate resting upon clay slates or shales. The boulders in the conglomerate are of crystalline rocks. No detailed examination of this important district having been made, our information with reference to the beds is extremely meagre.

The following is the list of fossils from the Gascoyne River beds:—*Pachypora tumida*, Hinde ; *Zaphrentis*, sp. ; *Amplexus pustulosus*, Hudl. ; *Amplexus nodulosus*, Phil.; *Syringopora reticulata*, Goldf. var. *patula* ; *Stenopora Tasmaniensis*, Londs ; *Cyathocrinus*, sp. ; *Poteriocrinus crassus*, Miller ; *Fenestella plebia (antiqua)*, M'Coy ; *Polypora Australis*, Hinde ; *Protoretepora ampla*, Lons. ; *Rhombopora tenuis*, Hinde ; *Evactinopora crucialis*, Hudl.; *Edestus Davisii*, H. Woodward ; *Aviculopecten Illawarensis*, Morris ; *Aviculopecten limaeformis*, Morris ; *Athyris Roysii*, Leveille ; *Athyris Macleayana*, Eth., fils.; *Spirifer striatus*, Martin ; *Spirifer* cf. *crassus*, Konin ; *Spirifer vespertilio*, G. Sow. ; *Spirifer cf. convolutus*, Phil. ; *Spirifer Kimberleyensis*, Foord ; *Spirifer lata*, M'Coy ; *Spirifer Hardmani*, Foord ; *Spirifer Musakheylensis*, *Dav.* Var. *Australis* ; *Syringothyris exsuperans*, de Kon.

The Irwin River Beds.—The existence of Carboniferous Rocks on the Irwin River would seem to have first been noted by Mr. Surveyor Gregory some time during the year 1846. Dr. F. Von Sommer, then Government Geologist, examined and reported on the scene of Gregory's discovery, and traced the formation from the head of the Irwin to the Moore River, a distance of about 160 miles.

The area was mapped in 1895 by H. P. Woodward, who at that time occupied the post of Government Geologist. This gentleman reports that the Carboniferous Rocks extend

From Mingenew in an Easterly direction, covering an area of about 20 square miles, its greatest length from North to South, from Badgeree Pool upon the North branch to Mount Scratch, being about 30 miles, whilst the greatest width from Mingenew to Narandagry, upon the Lockyer River, is about 17 miles. To the North-West this area is bounded by the high sandy tableland which extends away to the Northward as far as the Greenough River. The South is bounded for the most part by the low outcrops of metamorphic rock, which contains many copper lodes ; to the Eastward by the bold escarpment of crystalline rocks, flanked by horizontally bedded

Tertiary Sandstones, which often present towards the plains vertical cliff faces of as much as 200 feet, particularly where streams have cut deep channels through them; whilst to the Westward it is bounded by more high sandy plains which extend as far as the coast.

The Carboniferous Rocks of the Irwin River have yielded the following fossils:—*Pleurophyllum Australe*, Hinde; *Pleurophyllum sulcatum*, Hinde; *Fenestella*, sp.; *Productus tenuistriatus*, Vernueil; *Productus subquadratus*, Morris; *Productus undatus*, Defrance; *Chonetes Pratti*, Dav.; *Spirifer Musakheylensis*, Dav. var. *Australis*; *Syringothyris exsuperans*, Konin; *Reticularia lineata*, Martin; *Reticularia crebristria*, Morris; *Orthotetes crenistria*, Phil.; *Pachydomus carinatus*, Morris; *Aviculopecten*, sp.; *Modiola*, sp.; *Edmondia*, sp.; *Sanguinolites*, sp.; *Bellerophon decussatus* (?), Flem.; *Orthoceras*, sp.; *Discites*, sp.

Mesozoic Rocks.

The existence of rocks containing a secondary fauna would seem to have been first made known in the year 1861 by F. T. Gregory, in a paper communicated to the Geological Society of London by Sir Roderick Murchison. Mr. Gregory says these beds:—

> Are almost exclusively siliceous in character, containing only a few beds of chalk of very inferior quality. They abound, however, more in fossils than the Carboniferous do, and with the exception of the recent coast limestone, more so than any other formation. Flints are rarely found in these. The bed of the Greenough River is the best spot for procuring specimens, although a few are found in the Chalk Hills near Gingin (spines of Echinoderms, etc.).

Writing in 1863, Charles Moore observes that the bulk of the Mesozoic fossils from the Colony are of Jurassic Age, but in 1870, in a paper read before the Geological Society (of London), he expresses the opinion, based upon fossil evidence, that Cretaceous rocks occur in addition to those of Jurassic Age. Since that date, however, very few sectional details have been given of the Mesozoic Rocks of the Colony, although a fair collection of fossils has been made. These beds have been studied in the field by H. Y. L. Brown, who thus describes the strata, which he claims to be of Oolitic Age:— *

> The character of the Strata belonging to this Period may be described as follows:—Beds of highly ferruginous claystone or shale, sandstones grits, conglomerates, clays and limestone, placed in horizontal layers upon the older rocks, which originally they must have almost entirely covered, but have since been cut into and denuded to a great extent from off them, in such manner as to leave tablelands, isolated tablehills, and peaks with steep escarpments and slopes. Their average elevation is about 600 feet above sea level. The surface of this formation is generally coated with a deposit of sand, arising from the weathering of the sandstones, the larger areas being known by the name of sandplains. There are two principal areas occupied by this formation. The first, which varies in width from 10

* General Report on a Geological Exploration of that portion of the Colony of Western Australia lying Southward of the Murchison River and Westward of Esperance Bay. Perth: By Authority: 1873; pp. 11-14.

to 30 miles, extends from the neighbourhood of Gingin and Yatheroo to the Murchison, and probably a long distance further Northward, in a line more or less parallel to the coast. Proceeding Eastward, it thins out and only exists there as outliers and cappings on the hills. Its average thickness, where best developed, is some 400 feet. The second area commences near Cape Riche, and stretches in a North-East direction beyond the Phillips River, thinning out Eastward to mere cappings on the hills.

The uppermost beds in the first-named area are generally more ferruginous than the lower, and consist of highly ferruginous concretionary claystone, shale, and grit.

The great denudation which has operated since the close of this period has removed a great portion of the rocks, leaving the remainder as undulating plateaus and flat-topped hills, at the bases of which the older rocks outcrop. As a rule these strata are horizontal, although in some cases a slight undulating dip is perceptible. The interstratified beds of white, yellow, and sometimes ferruginous limestone, attaining the thickness of 30 feet, which occur chiefly in the neighbourhood of Champion Bay, do not seem to be persistent, but are found, as it were, in patches, which gradually thin out.

As the limestone composing them is made up of shells, which in some cases have consolidated into a solid rock, in others have retained their original form, it seems most probable that the accumulation of shells in hollows, in ancient sea-beds, is the cause of their now being found in isolated areas. The most common fossils found included species belonging to the genera *Ammonitidæ, Belemnitidæ, Ostreidæ, Pectenidæ, Trigonidæ, Rhynchonellidæ*, etc. These fossils are generally found in the limestone, whole masses of rock being composed of them; they are also found in the hard ferruginous shale and sandstone, in which case they have been converted into oxide of iron. In a paper published in the proceedings of the Geological Society, the author, Mr. C. Moore, considers the fossils from these beds to represent the fossil fauna of the Lias and the Lower Oolitic formations of England.

The whole chalky limestone of Gingin, Yatheroo, and Dandarragan, which outcrops from beneath the sandy soil of these localities in patches, most likely is also of Mesozoic Age.

As yet, owing to the surface accumulations of sand, etc., which hides it from view, no sections are to be seen which show whether it overlies or underlies the ferruginous rocks of the district. At different spots in the Darling Range, etc., beds of ferruginous grit, claystone, and conglomerate exist together with beds of unconsolidated sand which may belong to this formation. Between Brookhampton and the Upper Blackwood Bridge near Coverley's, and elsewhere along the road, on the tops and slopes of the moderately steep ranges which occur there, there are deposits of soft earthy claystone and ironstone containing perfectly polished boulders of reddish sandstone, grit, and quartzite, varying in weight from a few ounces to 50 pounds, and of more or less spherical and elliptical shapes.

It is difficult to imagine how these boulders, which have evidently (judging by their waterworn condition, and the absence of any similar rocks *in situ* in the district) been transported a considerable distance, and now occupy the tops of ranges, could have been placed in their present conditions except by glacial action, if such were possible in this latitude. The outside of the pebbles and boulders are, whenever the rock is hard enough, smoothly polished, but as far as I am aware there are no striæ or scratches on them.

The second principal area of this formation, which embraces the country extending from near Cape Riche to beyond the Phillips River, consists of a series of horizontal sandstones, grits, and conglomerates, capped generally by the usual ferruginous claystones, the whole thinning out on to

the granite along its northern boundary at a level of from 600 to 700 feet above the sea, and forming level plains and table hills, with steep escarpments along the Gardiner, Fitzgerald, Hamersley, Phillips, and Jerdicart Rivers. To the Southward and Eastward the formation, which attains a thickness of some 300 or 400 feet, rises on the slaty rocks of the Mount Barren and Jerdicart country. In lithological and stratagraphical character and position they are almost precisely similar to the same formation in the more Northern parts of the Colony. White marly saliferous sandstones, ferruginous grits and claystones, conglomerate reddish sandstones, etc., are the principal rocks met with. Perfect specimens of fossil sponges are frequent in some of the caves which occur along the escarpments, hanging from the roof and sides, where the rock has weathered away; worm casts are also abundant. Mainbenup, near Esperance Bay, is the farthest point Eastward where I have observed the formation. At Cape Riche beds of white and mottled sandstone, overlying granite, form low but steep cliffs along the shore of the bay.

Since the above was written the Mesozoic beds have received further attention, and our knowledge in connection with them has been materially increased.

Boring operations have been carried out in these beds in the vicinity of Geraldton, where the strata have been proved to consist chiefly of sandstones, etc., which attain a thickness of at least 1,100 feet.

It is possible that to the former horizon the Coal Measures of the Collie River may belong.

The following fossils have been obtained from the Mesozoic Rocks of this Colony:—*Cristellaria cultrata*, Montfort, *var radiata*, Moore; *Rhynchonella variabilis*, Schloth; *Avicula Munsteri*, Goldf.; *Avicula echinata*, Sow.; *Avicula inæquivalvis*, Sow.; *Lima proboscidea*, Sow.; *Lima punctata*, Sow.; *Ostrea Marshii*, Sow.; *Pecten cinctus*, Sow.; *Pecten calvus*, Munster; *Pecten Greenoughiensis*, Moore; *Astarte Cliftoni*, Moore; *Astarte apicalis*, Moore; *Cucullæa oblonga*, Sow.; *Cucullæa inflata*, Moore; *Cucullæa semistrata*, Moore; *Cardium*, sp.; *Cypricardia*, sp.; *Gresslya donaciformis*, Ag.; *Isocardia*, sp.; *Myacites liassianis*, Quenst.; *Myacites Sanfordii*, Moore; *Tancredia*, sp.; *Trigonia Moorei*, Lycett; *Pholadomya ovulum*, L. Agass.; *Teredo Australis*, Moore; *Unicardium*, sp.; *Amberleya*, sp.; *Cerithium Greenoughiensis*, Moore; *Eulima* (?), sp.; *Phasianella*, sp.; *Trochus*, sp.; *Turbo Australis*, Moore; *Turbo laevigatus*, Sow.; *Rissoina Australis*, Moore; *Belemnites*, sp.; *Belemnites canaliculatus*, Schloth; *Nautilus perornatus*, Crick; *Nautilus sinuatus*, Clarke; *Ammonites (Dorsetensia) Clarkei*, Crick; *Ammonites (Stephanoceras) Australe*, Crick; *Ammonites (Sphaeroceras ?) Woodwardi*, Crick; *Ammonites (Sphaeroceras) semiornatus*, Crick; *Ammonites (Perisphinctes) Championensis*, Crick; *Ammonites (Perisphinctes) robigonosus; Ammonites Aalensis*, *var Moorei*, Lycett; *Ammonites Walcottii*, Sow; Belemnites, sp.

Cainozoic Rocks.

The Cainozoic Rocks of the Colony occupy a very extensive area.

They are thus described by H. P. Woodward:—

Eocene.

Coralline and Chalky Limestones with Flints.—The beds extend the whole length of the Great Australian Bight, and for 150 miles inland. They present a bold vertical face, of great height to the sea, evidently marking the line of a fault.

Coralline Limestones.—These form the lower beds of the coast limestone, and contain a great many fossils of Eocene age, some of which were sent to England a few years ago to be described. The beds at Sharks Bay, and on the islands there, are probably of the same age.

The Calcareous and Ferruginous Sandstones, Grits, and Conglomerates.—These beds are met with between the limestone hills, and the ranges probably belong to this older Tertiary Series, as well as the ferruginous conglomerates which rest unconformably upon the Cretaceous Rocks to the Southward of Champion Bay.

Pliocene.

"Pindan"—Cracked Plains.—These large sandy plains are greatly developed on either side of the Fitzroy River and stretch far away to the Southward, where they form Warburton's Great Sandy Desert. On the Ord River there are also some small stretches of country of this character, but nowhere of any very great extent. Owing to its porous nature these plains are waterless in spite of the heavy rainfall, nevertheless, as a rule, they are covered with abundance of vegetation.

Sand Plains.—These form one of the characteristic features of Western Australia, extending as they do from one end of the Colony to the other. The great sand plains of the interior are often 20 or 30 miles across, but since they contain, in places, a good deal of the clay and iron which cement the grains of sand together, so that, there being a fair rainfall, they are covered with hardy vegetation, which during the two spring months is perfectly gorgeous with flowers, and they form good summer grazing ground. These sand plains mostly appear to overlie the desert sandstone formation which forms the table-land of the interior of Australia.

Ferruginous Sandstones and Variegated Clays.—Plant remains are met with in these beds on the lower courses of the Gascoyne River, also at the Nullagine; and similar rocks without the plant remains, cap the low ranges in many places throughout the Colony. They are probably of Upper Tertiary age, although they may be still more recent. Beds, probably of this age, containing large quantities of fossil wood, and beds of brown coal, are also met with below the coastal sand plains of the South.

Pleistocene.

Ancient river gravels and lake basins are found in several places in the ranges, and are similar in character to the deep leads of the Eastern colonies which proved so rich in gold. They consist of pipe-clay, ferruginous sands, gravel conglomerate, and mottled clay, and it is reported that Diprotodon bones have been found in one of these near Bridgetown, where these deposits are largely developed, and are now being worked for stream tin. Ancient river gravels are met with on the Nullagine and Ashburton goldfields, but, as a rule, they are not common in these districts.

Lower Estuarine Deposits.—These beds occur as far inland as Perth, where, in deepening the river channel, large quantities of oyster and other shells are met with, proving beyond a doubt, that the Swan was formerly a much larger arm of the sea than it is now. The oysters must have been exterminated by the silting up of the mouth of the river, which prevented the influx of salt water, keeping it fresh or brackish for a large part of the year. The deep holes in the bed of the Swan, to the West of Perth, prob-

ably owe their existence to the collapse of caverns eroded in the limestone which forms the bed of the river, by a subterranean flow of water containing carbonic acid.

Shelly Limestones and Sandstones.—These occur all along the South-Western coast, and contain fossils very similar to the living forms, upon which in many cases the nacre of the shell is still preserved. The shelly limestones and sandstones of Sharks Bay, and those met with here and there along the coast, as far North as North-West Cape, probably also belong to this series.

Recent.

Alluvium of Lake Basins.—Throughout the interior there is a series of what are called lakes, which are in reality nothing more than large salt flats, boggy marshes, or clay pans, almost on a dead level, that drain one into the other, and eventually, if the season has been wet enough, discharge themselves into the upper course of some river; but this rarely happens, owing to the enormous surface they present for evaporation. One result of this is that these large flats nearly every year receive a fine covering of clay, upon which the salts contained in the water crystallise out, to be redissolved and added to from time to time, till in some places, which may be a little lower than the rest, or where some obstruction occurs to check the flow of the water, very large deposits of salt accumulate. These lakes are surrounded by red clay flats which also contain a great deal of salt; in fact, the whole interior of the colony is salt, since the salts leached from the rocks are not carried away to the clay, to be redistributed over the surface of the country by the wind.

Salt and Gypsum Deposits.—Many of the lake basins are covered by deposits of salt and gypsum, the latter often occurring in the form of beautiful crystals (selenite).

River Valleys.—Loam deposits are formed by the rivers wearing away the old rocks, and carrying the finer material down from the hills and depositing it on the open level country, where it forms large rich plains. These deposits are often of great extent, spreading on either side from the rivers for a considerable distance. They are often very similar in character to those of the lake basins, but with this great difference, they contain less salt. They are best studied on the Upper Murchison, the Gascoyne, or Fitzroy Rivers, where there are large clay and loam flats, often many miles wide. These beds have probably been formed in the same manner as those of the lakes; but, having been better drained, the salt has been carried away by the rivers. Certain tracts, however, still contain much salt, which is replenished from time to time by large discharges of salt flood water from the lakes at the sources of the rivers. All the rivers North of the Greenough form these large flats, but those in the South form, instead, small deposits of clay, loam, sand, and gravel throughout their courses, which are very fertile.

River Gravels.—These consist of sand, gravel, and angular fragments of rock, and are found in the beds of the Northern streams, where large rivers are often as much as a mile wide. In the North there are some extensive alluvial deposits, following the sea coast, not generally situated in the river valleys themselves, but formed by the rivers in time of flood; they are not, as a rule, of any great thickness, because outcrops of rocks are frequent.

Brick Earth.—These deposits are met with in the valleys of many of the Southern rivers. They are of high quality, making excellent terra cotta ware, drain pipes, and bricks.

Estuarine Deposits.—These are met with at the mouths of the large Northern rivers, where there are periodical tropical and semi-tropical floods. The rivers bring down large quantities of mud, which they deposit near

their mouths, forming (excepting where coastal currents interfere) a kind of swampy delta, for the most part salt, overgrown with mangroves, and composed of a black, greasy mud, full in many places of recent petrifactions of crayfish, wood, and worm-tubes. The estuarine deposits of the South are of very slight account, for the rivers are comparatively small, having but short courses, and discharge themselves, on emerging from the gorges they have cut through the ranges, into the arms of the sea, which runs from the coast to the foot of the ranges. Moreover, they are but seldom flooded by excessive rainfall, and so bring down very little detritus.

Mangrove Swamps.—Black, muddy, salt swamps, covered with mangrove, fringe a great part of the coast North of North-West Cape, or that part where the tide has considerable rise and fall. They are situated just about high-water mark, and are therefore covered either by each high tide or only by the spring tides. Sand dunes occur along the West and South coasts at the river mouths, or where the land is low. They sometimes, as at Geraldton, reach a considerable height, and are a source of trouble, because they are constantly travelling unless kept carefully bushed or planted. Very often excellent water can be obtained beneath them, although that under the neighbouring flats may be bad.

Coastal Sand Plains.—These plains are met with in the Southern portion of the Colony, extending from the foot of the ranges, and cover the intervening lower ground between them and the sea. The sand here is much looser than in the interior, and is often of considerable thickness, of a red colour below the surface, and exhibits false bedding, which proves its origin to be Eolian or windblown. There are many lakes and swamps on the plains, the water in which is often held by deposits of peat.

Raised Beaches.—These were noticed by the late Mr. Hardman near Roebuck Bay, about 10 to 15 feet above the present sea level. One extends nearly 25 miles inland, and is from 12 to 18 miles wide. Its surface is covered with salt grass and samphire. Recent marine shells are found here and there, and in sinking a well a shelly deposit several feet in thickness, containing specimens of sea shells now found living on the coast, was passed through. Raised beaches of considerable extent are also met with at the foot of the Great Australian Bight.

Marine Shell Marls and Gravel.—These are of frequent occurrence along the coast between North-West Cape and the Leeuwin.

Surface Deposits.—Under this head come a large series of deposits not already referred to, the principal of which are the "gravel" and "ironstone," which cover a considerable extent of the South-Western portion of the Colony. These deposits are in reality indurated, nodular, ferruginous claystones called gravel, sometimes cemented by iron forming a conglomerate, and ferruginous sandstones, both of the latter being locally known as ironstone. They result from the disintegration of the different underlying formations (mostly crystalline rocks), and are most largely developed in the forest ranges, and it is upon them that the best jarrah grows. The so-called gravels are often of considerable thickness, and are largely used for ballasting railway lines. Their origin is difficult to understand, without it is due to bush fires, as they cap the highest ridges up to an elevation of 1,200 feet.

Volcanic Rocks.

Volcanic Rocks, claimed as being of Devonian Age, have been described by E. T. Hardman, from the Kimberley District :—

They consist of many varieties of basalt, including dolerite, and amanesite, trachy-dolerites, lavas, volcanic breccias, and ash beds, ferru-

ginous wackenite, etc., and . . . . occupy a very extensive area of the country to the East of the Ord. The basaltic rocks not only occupy a considerable superficial area, but they are also of considerable thickness. . . . . This formation occurs as a vast sheet or floor of volcanic rocks, which was formerly ejected and spread out over the Devonian Rocks, and subsequently in part denuded, and then covered by the Carboniferous deposits, and these in their turn being to a great extent carried away, the basalt has again been exposed over the extensive area where we now find it. That it is of an intermediate age between the Carboniferous and the supposed Devonian Rocks is certain, for within a short distance it is found resting on the one and covered by the rocks of the other formation, as at the junction (and a few miles below it) of the Panton and Elvire.

In the Ord District these rocks form a great plateau, as hereinbefore described. As a rule they show a distinct bedding, the lines of which dip inwards to the mountains at angles from 5 to 10 degrees. The traps are extremely varied in character; although they may be regarded as the same rock as a whole, still in the same neighbourhood many varieties of specimens can be obtained.

Ancient lavas and breccias are common amongst these rocks, and some of the latter would seem to have been deposited under water, as they are distinctly stratified. Volcanic ash or tufas, consisting of fragments of basalt, trachy-dolerite, lavas, etc., are met with also. In one locality, near Mt. Napier, the deposit contained large angular fragments of the easily-recognisable Devonian grits; the nearest place where such rocks are at present found being 40 miles distant. These fragmental deposits were, however, probably found not far from some ancient volcanic vent. No indications of such volcanoes were actually observed; but there are many high peaks and cones visible across the plateau, some of which may prove, on more careful examination than we were able to give, to be portions at least of the ancient craters. At the same time the country has been subjected to such a vast amount of denudation that it is only barely possible that any of them should retain their original form.

Ferruginous Wackenite, or "Wackenite Dolerite," is a rock which caps the summit of Mt. Napier. It is deep red in colour and somewhat columnar in structure. When broken into it appears like a mass of somewhat pebbly red hematite, but it is simply the result of the gradual decomposition of the basalt which forms this hill. This Wackenite cap is 20 or 25 feet thick.

Other basaltic rocks of undetermined age occur in the same neighbourhood; there are, however, very good reasons for believing that they belong to the same geological period as those last described. Mr. E. T. Hardman thus describes these rocks:—

Along the Western and Southern extremity of the Leopold Ranges a band of trap rock, about a quarter to half a mile in width, occurs. It has been traced from Mt. Phillip to Mt. Huxley, and is again seen in a deep gorge, which apparently cuts right through these hills, passing a quarter of a mile North of Mt. Huxley and continuing in an East-South-Easterly direction for about four miles. This chasm, which was named Straith-na-diaoul, is cut through quartzites and altered grits to the underlying trap rocks, which are about 500 yards wide; and these, as well as the band outside the range, have evidently been forced up long after the stratified rocks were deposited, as may be inferred from the manner in which those stratified rocks have been contorted and tossed about in the immediate vicinity of the traps. Here the traps pass from diorites into dolerites, and *vice versa*. Similar rocks are seen at the upper end of the gorge through which the Margaret passes, at J 11, where these basaltic rocks are seen in the river bed, and in the precipitous river walls for more than one and a-half

miles, and in places for more than a quarter of a mile in width. That this basaltic outburst is of later date than that of the overlying rocks is certain as the latter, which belong to the Metamorphic or Lower Silurian (?) system are upheaved by it to a considerable height and greatly contorted in places.

The character of the basalt here is similar in every respect to that near Mt. Huxley, and also to that of the flow basalts of the Antrim plateau. It is highly crystalline in places, and contains large quantities of olivine and epidote, with quartz veins.

Basaltic lavas are also known on the North-West coast to the South of Nullagine, and also on the Fortescue River.

Between Lake Cowan and Widgiemooltha the character of the country, according to the researches of S. Göczel, late Field Geologist, is such that:—

All circumstances point out that the diorites in this place are the remains of lava streams which have flowed from a volcanic centre situated between the Lakes Lefroy and Cowan, and to which also the formations of a watershed between the two lakes is due.

The same writer also states that:—

Lake Cowan occupies the depressions of an old volcanic region. . . . Nearly all the surrounding country of that lake consists of amphibolites, old greenstones, felsitic rocks and tuffs. The North-Western shore is approached by gneiss-granite hills, often covered with amphibolites or greenstone cappings. The Palæozoic volcanic rocks become more and more predominant as we approach towards the lake, beneath which the gneiss-granite completely disappears. Along the Western shore of the lake the great break in the Archæan strata is most pronounced, and the rugged mountains and hills extending along the shores and forming islands in the lake are ruins of old volcanoes, which in their time were of similar build to the strata volcanoes of later periods.*

Basaltic lava is also known at Bunbury; here a mass of columnar basalt rises about 20 feet above sea level. Similar basalt again makes its appearance about five miles to the South of the Capel River. Basalt has also been described as occurring on the South Coast, to the East of Flinders Bay, at Black Point.

* "Geological Notes and Sketches." S. Göczel. Appendix vi. *Ad interim* Report on the Department of Mines for the half-year ending 30th June, 1894. Perth: By Authority, 1894; pp. 36 *et seq.*

CHAPTER II.

GOLD.

General.—Gold Matrices, Associated Minerals, Purity of Western Australian Gold. Kimberley, Pilbarra, West Pilbarra, Ashburton, Gascoyne, Peak Hill, Murchison, and East Murchison Goldfields.

General.—The auriferous deposits of Western Australia have been responsible for the 4,127,374 ounces of gold, valued at £15,684,022, which have been exported. The relations which these deposits, one of the factors of the Colony's prosperity, bear to the broader geological features, naturally take a prominent place in any account dealing with its mineral resources. The method adopted in dealing with the auriferous deposits is to describe each goldfield separately, giving a brief *aperçu* of its salient features, although the information available for this purpose is, in one or two cases, much more fragmentary than could be wished. It has been found most convenient to adhere to a strictly geographical order in description, beginning with the field at the Northern extremity of the Colony. The description of each field is followed by a table, giving the yield of gold as shown by (*a*) the figures furnished to the Department of Mines; and by (*b*) the data in the archives of H.M. Customs House. It will be noticed that in all cases there is a difference between the two sets of figures. Up to the end of 1899 there have been officially reported to the Mines Department 3,850,332 ounces of gold from the various fields of the Colony; the Customs authorities, however, give 4,127,374 ounces as that entered for export, being 277,042 ounces in excess of the figures furnished to the Mines Department. The discrepancy is to be accounted for by the difficulty experienced in obtaining a record of the alluvial gold, and also by the fact that a good deal of the gold won in the early days was probably never officially reported. Writing in 1899, the Warden of Yilgarn notes, with reference to the output of gold from that district, that "a good deal of gold leaves the field and is not recorded." *

As alluded to in the previous chapter, the crystalline rocks—the matrices of the auriferous deposits—are divided into three broad parallel belts, formed of granite, gneiss, and schist, which trend generally North-West and South-East. Observations have

* Report of the Department of Mines for the year 1898. Perth: By Authority: 1899; p. LXXV.

shown that there are two fairly well defined, and more or less continuous ore-bearing belts which have a distinct relation to the geotectonic features of the crystalline rocks. The schists which constitute the principal auriferous belts form long and comparatively narrow bands or attenuated elliptical patches. The schists consist of mica, chlorite, sericite, hornblende, and quartz, and serpentinous schists together with hematite-bearing quartzites.

All the important auriferous areas occur within the limits, or in the immediate vicinity of country occupied by the schistose rocks. These auriferous belts occupy a very large area of country, extending from the South Coast to the country lying between Spit Point and Cape Lambert, on the North-West Coast, extending over about 14 degrees of latitude. The auriferous belts exceed twenty miles in width in places. There is a larger area of auriferous country exposed at the surface than in any other portion of Australasia.

At my request the Mineralogist and Assayer has furnished the following brief account of the gold matrices, so far as can be judged by work in the laboratory; as far as possible his own words have been adhered to, though some slight condensation has been made in certain places.

Gold Matrices.—Over the area occupied by the auriferous schistose rocks, the ore deposits fall naturally into two broad divisions.

(*a*.) Lodes and other deposits in which the concentration of the precious metal has been subsequent to the formation of the enclosing rock.

(*b*.) Original alluvial deposits in which the gold has been concentrated by mechanical action contemporaneously with the formation of the rock itself.

The deposits included in Class *A* may be further sub-divided into (1) veins, including stockworks; (2) dykes; (3) deep-reaching impregnations of zones of rock; (4) shallow impregnations of surface material. They are found chiefly in amphibolites and hornblende schists, but chloritic schists of somewhat doubtful origin frequently constitute the enclosing rocks mass, and in the Northern parts of the Colony mica schists, slates, and quartzites or sandstones are also found as matrices.

(1.) *Veins.*—The gangue material of most of these is quartz, but other minerals in places largely replace it, as, for instance, dolomite and other carbonates at Red Hill, Coolgardie Goldfield, and Vosperton. The quartz reefs of Coolgardie, Norseman, Southern Cross, Menzies, Cue, Wiluna, Salgash, Mt. Magnet, and Ruby Creek has been largely responsible for a very considerable proportion of the total production of gold from those districts, but at other centres, such as Kalgoorlie and Kanowna, have been of minor importance. The quartz of these veins in the Southern and

Central portions of the Colony is usually milky white, but further North is frequently transparent and of a bluish tinge. Stockworks of quartz veins in felsite or other dyke rocks have yielded payable gold in Coolgardie, Bardoc, and Kalgoorlie, whilst fault-breccias, which form the connecting link between this and the third class, have been worked in Coolgardie, Menzies, and Mt. Magnet.

(2.) *Dykes* of felsite and acid porphyries associated with the older basic schists are occasionally found to carry a considerable quantity of gold, both in the solid rock and in the quartz stockworks which it encloses. Instances of this form of deposit are to be found at Londonderry, Burbanks, and Bardoc.

(3.) *Impregnations of Zones of Rock.*—These form the most interesting and possibly the most important source of the precious metal in Western Australia. They consist of bands of much fissured rocks merging insensibly into more solid rock of similar origin and constitution on both sides. They are both known to the miners as "lode formations." Being merely portions of a large mass of rock, which in consequence of dynamical agencies has permitted of the free circulation and subsequent deposition of mineral solutions, these deposits are characterised by having no well-defined walls, the limits of the deposit being determined by the decrease in the assay value of the rock to a point at which it ceases to pay the expenses of working. The most notable development of deposits of this description is to be found at Kalgoorlie, from which, from 1895 to 1899, something like one and a-half million ounces of gold have been extracted. In this area the chief rock developed is a chloritic schist, which may be an acid porphyry now highly foliated and otherwise altered. A similar rock occurs under like conditions, and is auriferous, at Kanowna, whilst at Peak Hill a notable amount of gold is derived from quartz schists and other foliated rocks. At Mount Leonora and at Norseman, especially the former, similar deposits have also yielded payable ore. To this class are to be referred the ore bands of chalcedonic quartz and jasperoid rocks which are of such frequent occurrence in the Colony, and which contain payable gold in such widely separated localities as Black Flag, Mount Magnet, and Horseshoe. Bands of rock, generally more or less foliated, are frequently found to be auriferous in close proximity to rich quartz reefs. Gold is thus found in serpentine schist and amphibolite at Coolgardie, in amphibolite at Bardoc, in sandstone at Donnybrook, and slate in the Kimberley district.

The auriferous conglomerate beds of Nullagine are also to be referred to this class, the gold in them being of secondary nature, and occurring in somewhat well defined bands.

(4.) *Shallow Impregnations of Surface Material.*—The upper portions of the old rock surface immediately underlying the richer leads at Kanowna have been found to contain payable gold in many places, and have been worked out with the latter. The rock consists of decomposed porphyry and chloritic schists, and most if not

all of the gold in it is in the form of fine scales on the cleavage planes, showing that the enrichment of the stone with the gold has been largely subsequent to weathering of the rock. The so-called "pug" of Kanowna, a bedded kaolin of comparatively recent age overlying the coarser auriferous wash, is externally rich in places owing to the large development of crystalline and leaf gold in its cleavage planes. This is probably a further example of this class which is found to pass imperceptibly into the true original alluvial deposits.

The deposits included in Class *B* comprise (1.) residuary soils and gravels; and (2.) alluvial deposits.

(1.) *Residuary Soils and Gravels.*—In such districts as Kalgoorlie, where the rainfall is very slight, and where rich gold-bearing rocks outcrop frequently on comparatively flat ground, the surface soil resulting from the decomposition *in situ* of these rocks is highly auriferous, a natural cause of concentration being the removal of the lighter portions of the soil by the wind. Much of the surface gold of Western Australia has been derived from deposits of this nature, especially at Boulder and Coolgardie, where much of the alluvial of Fly Flat, at least, was merely the decomposed residue of auriferous felsite dykes. These residuary deposits pass insensibly into:—

(2.) *Alluvial Deposits.*—These may be roughly divided into recent accumulations still in process of formation, and older deposits no longer being enriched by the addition of fresh gold-bearing material. Examples of the former are to be found in every district where reef gold is being obtained, and, in the interior of the Colony where the rainfall is small, are never at any great distance from the parent ore body. The material of which these deposits are composed is generally a more or less ferruginous sandy clay, frequently carrying much travertine. Of this nature are the more recent deposits of Bardoc, Kalgoorlie, and Coolgardie. On the Pilbarra and other Northern fields, where the rainfall at certain seasons is very heavy, a considerable quantity of gold is recovered from the river sands and gravels of the usual nature. The dry lakes of the interior, occupying as they do the lowest lying portions of the country, have long been suspected of containing in their sandy beds material which would pay to treat on a large scale. The last division of gold deposits embraces those older alluviums which have, so far, only been worked in six places, viz., Kanowna, Bulong, Broad Arrow, Kalgoorlie, Kintore, and The Island, Lake Austin. At Kintore (Coolgardie Goldfield) the gold occurs in a series of beds of sandstone, conglomerate, and kaolin, forming the remnants of an old river deposit on a granite bedrock. At Kanowna, the deposits are of two distinct ages, (1) the older siliceous conglomerate ("cement") outcropping at the surface, and now quite vitreous from the development of secondary silica; (2) the newer deposits of the deep-leads, consisting of a series of sands, gravels, clays, magnesia, travertine, vitreous sandstone, and conglomerate, all of which carry payable gold.

Associated Minerals.—Of the metallic minerals which are found to accompany gold in Western Australia, by far the most important is iron pyrites, which, with its concomitant oxides of iron, is found in every ore body from Kimberley to Dundas. Not only is this mineral found in close conjunction with free gold, but in many instances, such as at Red Hill (Coolgardie Goldfield), is found itself to carry a considerable amount of gold imperceptible to the naked eye. As a rule, the pyrites does not constitute more than four or five per cent. of the gangue, but at some mines in Menzies and Mt. Ida, amongst other places, it forms one-half or more of the latter.

Next in order of importance after pyrites is galena. It occurs in the gold reefs of Hall's Creek, Brockman's, and all the other Kimberley centres; but it is found that the richer the stone in galena the poorer in gold. Galena also occurs in conjunction with gold at Tambourah and Horseshoe.

Vanadinite has been detected with gold at Coolgardie and Pinyalling.

Arsenopyrite accompanies gold at Ruby Creek, Niagara, and Coolgardie. Some beautiful specimens of this mineral have been obtained from Bayley's United Gold Mine at Coolgardie. They consist of veined arsenopyrite traversed in every direction by a network of veins of gold, varying in width from 1-20th of an inch down to a microscopic thickness.

Zinc Blende is an indication of rich ore at Yandicoogina, Coolgardie, and Lawlers; in each instance, however, forming a very small proportion only of the total gangue.

Native bismuth and bismutite are found in auriferous quartz at Burbanks, Dundas, Yalgoo, and Lawlers. At Burbanks the native bismuth is alloyed with gold to the extent of about one per cent. The bismuth at Lawlers is also, in all probability, alloyed with gold, since the surrounding scales of bismutite are thick with fine scales of metallic gold.

Pyrrhotite occurs in the quartz reefs of Southern Cross and Burbanks; in neither of which instances is it nickeliferous.

Chalcopyrite and copper carbonates occur in association with gold at Coolgardie, Sir Samuel, Tambourah, Hall's Creek, Gorge Creek, and many of the Murchison centres.

Bournonite is of frequent occurrence in the beds at Kalgoorlie, and is also said to accompany gold at Wiluna.

Native copper is reported from Coolgardie, Sir Samuel, and Roebourne.

Scheelite occurs in bunches in auriferous reefs at Coolgardie and Southern Cross, but in both instances is characteristic of poor ore.

Exceptional occurrences are those of Calverite, Coloradoite, Kalgoorlite, and other tellurides together with Bournonite and Löllingite in the Kalgoorlie ores, and of Native Silver in auriferous quartz at Nannine. So too, is that of Asbolite rich in cobalt and carrying freely visible gold at Kanowna.

Of the earthy secondary minerals which accompany gold in Western Australia quartz is the most important here as elsewhere. Gold occurs in veins of calcite, more or less magnesian, at Mary River, Panton River, Kalgoorlie, Kanowna, and Red Hill (Coolgardie Goldfield). Chalcedony occurs in many quartz veins, and is characteristic of much of the better ore at Donnybrook. Gold has been found in gypsum at The Island, Lake Austin, and is of frequent occurrence in the oxidised zone at Kalgoorlie. Actinolite, chlorite, and other minerals derived from the enclosing rock mass are found in many quartz reefs, but probably owe their origin to agencies other than those which caused the deposition of the gold, and are for that reason of little interest.

Purity of Western Australian Gold.

In order to calculate the value of the exports of the Colony, the Customs authorities have assumed an average value of £3 16s. per ounce, or a fineness of 894·7 for all the gold bullion turned out by the various mines. Seeing however that the purity of this bullion depends not only on the purity of the metal in the ore, but also upon the nature of the other minerals in it, the method of extraction, and the degree to which the refining process is pushed at the mine, this factor gives but little idea of the original fineness of the metal.

No analyses of the native metal from Western Australia would appear to have ever been published, but the following few figures were obtained in the laboratory of the Geological Survey at Perth :—

No.	Nature of Gold.	Locality.	Specific Gravity	Gold.	Silver.	Copper and Iron.
1	Small alluvial nuggets	Hall's Creek, Kimberley Goldfield	16·62	933·0	66·0	1·0
2	3oz. alluvial nugget carrying quartz	Do.	16·80	883·9	116·1	?
3	"Bobby Dazzler" quartz nugget	Shark's Gully, Pilbarra Goldfield	14·66	768·1	230·4	1·5
4	Gold from quartz boulders	Talga, Pilbarra Goldfield	16·20	844·6	155·4	?
5	Gold from quartz reef	Peak Hill, Peak Hill Goldfield	17·16	965·4	34·6	
6	Coarse gold in quartz reef	Nannine, Murchison Goldfield	15·75	894·5	105·0	·5
7	Crystalline gold from calcite vein	Red Hill, Coolgardie Goldfield	18·00	932·1	67·2	·7
8	Gold from conglomerate bed	Nullagine, Pilbarra Goldfield	...	912·1	87·9	
9	Coarse gold from ironstone pebbles	Block 50, Hampton Plains	18·91	994·6	6·4	Trace

The last analysis is of special interest as this gold appears to be the purest on record, except that from Mt. Morgan, Queensland.

THE GOLDFIELDS.

Kimberley Goldfield.

The most Northerly goldfield in the Colony is that of Kimberley, which was discovered in 1882 by Mr. E. T. Hardman, then Government Geologist.

The goldfield, which embraces an area of about 47,600 square miles, was proclaimed on the 20th May, 1886. The boundaries, as defined by the authorities, are as follows:—

Bounded on the North by the 16th parallel of South latitude; on the South by the Southern boundary of the Kimberley District (latitude 19° 30′ South); on the West by the 126th Meridian of East longitude; and on the East by the Eastern boundary of the Colony (longitude 129° East).

The strata exposed on the goldfield consist of crystalline schists of Archæan age, together with representatives of Cambrian, Devonian, and Carboniferous rocks, as well as a large development of volcanic rocks.

The *Carboniferous Rocks* of Kimberley occupy a very large extent of country, and have been estimated to cover an area of about 2,000 square miles.

The beds, which attain a maximum thickness of about 2,500 feet, are said to owe their preservation to a well-marked fault which trends North-West and South-East. The rocks consist of sandstones, grits, and conglomerates, with limestones and sandy shales. The strata lie practically horizontally. The calcareous beds of the Lower Series form bold precipitous escarpments, such as those in the Geikie, and the Napier Ranges. The formation has yielded a suite of Carboniferous fossils.

The *Devonian Rocks* of Kimberley occupy an extensive area of country; they are seen to rest directly upon older rocks, and to be covered by basaltic lavas which are overlaid by beds containing Carboniferous fossils. The beds consist of almost horizontally-bedded hard, grey, red, or green grits and conglomerates, associated with highly indurated limestones and shales. The formation attains a maximum thickness of about 1,000 feet, and has proved to be fossiliferous.

Cambrian Rocks have been identified by palæontological evidence from certain portions of the district. The beds consist of highly inclined crystalline limestones, sandstones, grits, quartzites, clay slates, etc., and have yielded *Salterella Hardmani*, and *Olenellus (?) Forresti*. This formation is of considerable economic importance, in that it is amongst these beds that the principal gold deposits have been discovered. So far as present observations have been carried, the formation extends in a North-East and South-West direction, from the Burt Range to the South of Mt. Dockrell.

The beds have been folded in such a manner that the principal axes trend North-East and South-West. No observations have as yet been made with the view of determining the thickness of the formation.

The *Crystalline Schists* and allied rocks are highly developed in Kimberley. They consist of micaceous and talcose schists, gneiss, and granite. They have been proved to extend from near Denham River to Mount Dockrell, and appear again in the Mueller Range, a little further West, and striking North-Westwards pass through the King Leopold Range to King's Sound. This belt of rocks varies in width from 10 to 30 miles, and has been proved to have a horizontal extent of at least 120 miles. The crystalline schists have been folded in a North-West and South-East direction, with a secondary folding in a direction approximately at right angles to this.

Mining operations on the Kimberley field have been chiefly confined to six principal centres, viz., The Panton, Hall's Creek (the official centre of the field), Brockman's, Ruby Creek, The Mary River, and Mount Dockrell.

Up to the end of 1899, the Kimberley field has yielded, according to the Mines Department figures, 14,320ozs. of gold; the Customs authorities, however, report that up to the same date 25,029ozs. have been entered for export. There is thus a discrepancy of 10,709ozs. between the two different sets of figures. This difference may in all probability represent the yield of alluvial gold, which, unless under exceptional circumstances, is never reported to the Government.

Writing in 1895, Mr. E. T. Hardman thus refers to the Quartz Reefs of Kimberley:—

. . . Quartz reefs and veins are very numerous, but most especially so in the gneissose and schistose rocks. In the granites below the Leopold Ranges they are not very abundant, although often noticeable. Here they strike usually East and West, or a little to the North of West; but in all the metamorphic rocks to the Eastward they are found plentifully. In many places these quartz veins look to be promising for metals, and often contain quantities of black iron sand, iron pyrites, etc. They vary in thickness from one to eight feet. The schistose country, stretching from the McClintock Ranges to the North-North-East, is traversed by an enormous number of quartz reefs. In some localities many of these occur in the space of a few hundred yards, and it was quite usual to notice 25 or 30 large reefs, veins, or strings. The quartz constituting these reefs is of a very favourable character. It is a dull, yellowish and grey quartz, very cellular and ruggy, containing quantities of black and other oxides of iron, together with casts of, and often crystals of, iron pyrites. From most of the surface quartz the enclosed minerals have been washed away, however, although their traces are still apparent. Minute specks of gold have been noticed in a few cases, and I have very little doubt that many of these reefs, when properly examined and tested, will prove to be auriferous. The quartz reefs in this part of the country have a bearing of North 10 degrees West to North-East; many run due North and South; some of them can be traced for many miles.*

* The Geology of the Kimberley district. E. T. Hardman, Perth: By Authority: 1885; p. 22.

At the Panton River there would seem to be two series of reefs, the first of which, striking North-East and South-West, consists of true veins. Although small in size, they can be traced for a considerable distance at the surface, and it is on this series that most of the claims were taken up. The second series appear at the surface as large quartz blows, striking East and West, cutting across the smaller veins, but they cannot be traced for any distance at the surface, and, up to the present, gold has only been found in one reef at the extreme Western edge of the field, close to the Mackintosh Hills. *

Yield of Kimberley Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons. cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1886			202 0 0	
1887			4,873 0 0	
1888			3,493 0 0	
1889			2,464 0 0	
1890			4,474 0 0	
1891	*a* 13,199 10 0	12,733 19 23	2,699 12 8	*a* Details not available.
1892			1,088 16 22	
1893			1,621 13 23	
1894			588 12 17	
1895			876 13 16	
1896			891 17 6	
1897	383 10 0	229 6 0	554 1 12	
1898	175 0 0	*b* 440 3 10	287 17 17	*b* Inclusive of 310ozs. of alluvial.
1899	694 0 0	*c* 917 3 0	814 7 6	*c* Includes 417ozs. of alluvial.
Total	**14,452 0 0**	**14,320 12 9**	**25,029 13 7**	

Pilbarra Goldfield.

The Pilbarra Goldfield was proclaimed on the 19th September, 1895; it embraces an area of 35,100 square miles.

Its boundaries, as defined by the authorities, are as follows :—

Bounded by a line starting from a point on the Sea coast Eastward from Condon Creek and extending through the summit of Poolingerena (or Mount Blaze) to a spot due North from the summit of Mount Macpherson; then South through the said summit to a spot due East from the summit from Mount Marsh, on the upper Fortescue River; thence due West through the summit of Mount Marsh to the right bank of the Fortescue River, along it downwards to Survey Station V23; thence in a Northerly direction through Survey Station V32 to the right bank of the Cocreaca branch of the Yule River, and along the right bank of the Cocreaca Creek and the Yule River downwards to the Sea coast, and along the Sea coast Eastward to the starting point.

Very little is known with reference to the geology of the Pilbarra goldfield, for with the exception of a hurried visit by the ex-Government Geologist some years ago, no official examination of the district has been made.

* Mining Handbook to the Colony of Western Australia. H. P. Woodward Perth. By Authority: 1895; p. 74.

So far as observations have at present been carried, it would seem that a large portion of the goldfield consists of granite and other crystalline rocks, intersected with dykes of diorite, and associated with slates, sandstones, limestones, quartzites and conglomerates. There seems to be an upper horizontally-bedded series of strata, resting upon crystalline rocks, across the strike of which several large rivers have cut their channels. The superficial area, or thickness of these strata, and their structural relationship have not yet been worked out, hence our information in connection with them is much more meagre than could be desired.

There are six principal mining centres on the goldfield, viz., Bamboo Creek, Talga Talga, Nullagine, Marble Bar, the Shaw, and Tambourah.

Bamboo Creek consists of granite and granitic gneiss (foliated granite?) striking North-East, and associated with quartzites and diorite dykes. The quartz reefs, said to be small where exposed on the surface, widen out in depth; in one instance, in the "Bulletin" Mine, the reef attains a thickness of as much as 10 to 12 feet. The quartz is associated with ores of iron, copper, lead, and manganese.

The rocks in the vicinity of Talga Talga consist of diorite, quartzite, and Jaspideous rocks. The quartzites trend slightly to the East of North, and underlie at a high angle to the Westward. The quartz reefs are said to be well defined, and associated with ores of iron, copper, and manganese.

The mining centre of Nullagine is situated about 180 miles South-South-East of Condon, and 300 miles East-South-East of Roebourne.

The staple formation in the vicinity of Nullagine consists of grits, slates, sandstones, and conglomerates, striking North-East, and dipping at low angles to the North-West. Flat table-topped hills of conglomerate and cement occur in the vicinity; these beds are newer than the slates and other associated rocks referred to. Underlying the cement, much of which is either a compact body of ironstone conglomerate or nearly pure hematite, is a deposit of kaolin from 10 feet to 50 feet in thickness. This conglomerate, some portions of which are very vesicular, has been successfully worked for the gold it contains; crushings from the outcrops have yielded as much as 2ozs. to 4ozs. of gold to the ton. The conglomerate occurs in ranges which rise to about 100 to 150 feet above the level of the surrounding country.

The hills . . . . . upon which the chief mine workings are at present situated, appear to be mostly round-backed and strewn with rounded boulders and pebbles. On closer examination one finds that they consist of bed upon bed of conglomerate, merging into intermediate layers of kaolin. The beds dip universally to the North-West and strike North-East and South-West. The dip is flat, averaging perhaps 15 degrees. Therefore, as one approaches from the South-East the hillsides exhibit longitudinal sections of the country, and in some cross-gorges very complete studies may be made of cross-sections, whilst, where the rounded weathered hillsides slope to the flat, one may notice somewhat regular lines of round boulders and pebbles roughly marking the outcrops of the conglomerate beds. By these

indications, and also by following up the runs of alluvial gold until they stopped all along certain horizontal lines, the auriferous conglomerates were originally located and worked by prospectors by means of drifts and tunnels. Some of the conglomerate beds contain boulders up to three or four feet in diameter, while others carry nothing bigger than a man's head. These boulders consist of rounded masses of quartz, traprocks, and other conglomerates. A peculiar feature about the shape of these is that they are very often somewhat flattened like curling-stones.*

Some samples of the auriferous conglomerate have been examined in the Survey Laboratory, and have been thus described:—

A specimen typical of the finer grained portions of the rock in its upper decomposed portions. It consists of sub-angular fragments of quartz, ironstone and shale, cemented together by ironstained kaolin, containing numerous cuboidal cavities at one time filled by pyrites crystals, as shown by the numerous pseudomorphs of limonite contained by them. There are several much weathered volcanic bombs embedded in the rock. It assays 1oz. 6dwts. of gold, for which metal it is treated on a large scale by the battery amalgamation process. A similar but less ferruginous variety showed no cavities vacated by pyrites and is much coarser in grain, some of the fragments of quartz being 3 inches in length. It assays 2ozs. 1dwt. of gold per ton.

Another variety made up of large pieces of felstone, with smaller fragments of quartz, imbedded in a kaolinic matrix, assayed 10dwts. of fine gold, and 5ozs. 4dwts. of coarse gold per ton.†

In some respects this auriferous conglomerate bears a close resemblance to those auriferous conglomerates of the Rand, better known perhaps as Banket deposits.

In the vicinity of Nullagine are a series of older slaty rocks, which dip to the North-West at a low angle, and which have proved of importance in that they form the matrix of numerous auriferous quartz reefs and leaders.

The main reefs, however, run with the country, striking North-East. The surface is strewn with their *débris*, and dry-blowers have gathered good harvests therefrom. About three years ago attention was attracted to the reefs themselves by the discovery of several very rich patches of stone on their outcrops, and since then a considerable amount of mining has been done and many good crushings have been taken out. The character of the quartz in the big reefs is mostly very white and vitreous, and in this kind of stone the gold is generally coarse and occurs in bunches; while in smaller reefs, and sometimes in certain splices of the big ones, a more kindly-natured stone is found, showing perhaps fine gold and prospecting well all through.‡

Alluvial workings of three classes occur:—1st, the alluvium of existing creeks; 2nd, the alluvium of older creek beds, but in conjunction with the present streams; 3rd, old alluvial deposits or deep-leads bearing no relation to existing streams or configuration of the country. The most recent deposits are easily worked, for Nature is at work here to-day ground sluicing *débris* from the older formations, therefore no sinking is required, and the dirt is so free that it can easily be dry-blown. The older alluvial deposits are found in the river flats, where auriferous gutters are crossed

* The Nullagine District, Pilbarra Goldfield, Western Australia. S. J. Becher. Trans. Inst. M.E. (Newcastle) Vol. XVI. Pt. 1, 1898; pp. 48-9.

† Annual Progress Report of the Geological Survey for the year 1897. Perth: By Authority: 1898; p. 48.

S. J. Becher. *Loc. Cit.*

and recrossed by the present streams. The sinking here is about 10 feet, and very hard work, owing to the fact that the deposits that overlay the dirt are cemented masses of quartz and boulders of other hard rocks.

The deep leads are cut across by the present valleys, and can be traced from hill to hill. Here the sinking is very variable in depth, the whole gutter in some places appearing on the side of a cliff where the work merely consists in driving, while in other places shafts up to 60 or 70 feet have to be sunk to work the same lead. Up to the present only one of these leads has been discovered, but there cannot be the least doubt that more will be found when the small hills between the conglomerate range and the creek are thoroughly prospected. All three of these deposits are very rich, but no one can estimate the quantity of gold with any degree of accuracy, as so much leaves the Colony without ever being reported.*

Marble Bar, the official centre of the Pilbarra Goldfield, derived its name from a mottled bed of quartzite, which crosses the Coongan River in close proximity to the town. Quartz reefs are very prominent in the district, and vary very much in size and character, some of the quartz being very highly mineralised. Many of the reefs have proved exceedingly rich. A considerable quantity of gold has been derived from alluvial deposits in the early days of the field.

The country rock of the Shaw Diggings consists chiefly of granite, associated with schistose rocks, quartzite, and diorite dykes. The strata inclined at high angles to the Westward. The reefs are well-defined and exhibit well-marked lateral continuity.

The mining centre of Tambourah lies near the junction of an enormous mass of granite and hornblende, schists and diorite. The reefs as seen outcropping on the surface are small, but widen out in depth. The quartz is associated with ores of iron, copper, and manganese.

The following table shows the yield of the Pilbarra Goldfield up to the close of 1899, as deduced from official data:—

Yield of Pilbarra Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1889	c			b 22,582	11	0	a 11,170	0	0	a. Includes export from West Pilbarra.
1890							a 16,055	6	6	b. Includes 2,082ozs. from unknown tons.
1891							a 11,875	0	0	
1892							a 12,892	16	0	c. Details not available.
1893							a 11,698	10	0	
1894							a 16,254	10	0	d. Includes 427ozs. from West Pilbarra.
1895							a 19,522	8	0	
1896	4,270	0	0	d 5,888	0	0	a 11,810	2	4	e. Includes 2,000ozs. of alluvial and 102ozs. dollied and specimens.
1897	5,138	14	0	6,825	5	7	a 11,955	17	9	
1898	6,719	15	0	e 14,413	15	23	11,962	11	5	
1899	7,587	11	0	f 19,316	19	13	19,996	8	1	f. Includes 2,608ozs. 5 dwts. 18grs. of alluvial, and 833ozs. 14dwts. 9 grs. dollied and specimens.
Total	**23,716**	**0**	**0**	**69,026**	**11**	**19**	**154,893**	**9**	**1**	

* Annual General Report for the year 1890. H. P. Woodward, Perth: By Authority: 1891; p. 25.

West Pilbarra Goldfield.

The West Pilbarra Goldfield, about 10,500 square miles in extent, originally included in the Pilbarra Goldfield, was created a separate field on the 19th of September, 1895.

The authorities define the boundaries as follows :—

The portion of Crown lands bounded by a line starting from the Sea coast, at the mouth of the Fortescue River, and extending along the right bank of the said river upwards to Survey Station V23; thence in a Northerly direction through Survey Station V32, to the right bank of the Cocreaca branch of the Yule River, and the right bank of the Cocreaca Creek and the Yule River, downwards to the Sea coast, and along the Sea coast Westwards to the starting point.

Very little is known with reference to the geological features of the West Pilbarra field.

Mining operations, however, are confined at the present time to but a few centres.

The Mallina Diggings, the scene of the first discovery of gold in the North-West in 1888, lie about 70 miles East of Roebourne. The gold in the reefs is associated with sulphide of antimony.

Toweranna Diggings lie about 14 miles South of Malina. The country rocks consist of schists, slates, porphyry, and diorite. The quartz of the reefs is of a blue colour, and contain ore of lead and iron disseminated through it.

The mining centre of Pilbarra, from which the field originally derived its name, lies within the drainage area of one of the heads of the Yule River. A fairly large quantity of alluvial gold has been obtained from a narrow strip of country at the junction of granite and metamorphic rocks.

Yield of the West Pilbarra Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons. cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1889			*a*	
1890			*a*	
1891			*a*	
1892			*a*	
1893	160 0 0 (1889–1896)	337 18 0 (1889–1896)	*a*	*a* Previously shown in the Pilbarra (*Vide ante*).
1894			*a*	
1895			*a*	
1896			*a*	
1897	608 17 0	860 1 10	*a*	
1898	202 6 0	326 14 0	2,028 5 10	
1899	879 17 0	*b*1,934 16 1	1,955 10 2	*b* Including 735ozs. 1dwt. 11grs. alluvial.
Total	**1,851 0 0**	**3,459 9 11**	**3,983 15 12**	

Ashburton Goldfield.

The Ashburton Goldfield was proclaimed on the 25th December, 1890, and on the 25th of June, 1897, the boundaries were somewhat amended, and the field reduced in area to about 6,992 square miles.

As at present constituted the boundaries as defined by the authorities are as follows:—

Bounded by lines starting from the summit of Mount Elizabeth, which is situated about six and one-half miles from the junction of Duck Creek with the Ashburton River, and extending East by North to the summit of Mount Edith; thence South-East by East to the summit of Mount DeCourcey; thence about East by South to the summit of Mount Wall; thence about South-East by East to Trig. Station 10/\; thence about South-East by South to the summit of Mount Bresnahan; thence about South-West by South 37 miles towards Trig. Station K20; thence by a line running about North-West by West to the summit of Mount Palgrave; thence North by West to the summit of Mount Florry; thence North by East to the summit of Mount Elizabeth, the starting point.

The Ashburton Goldfield never having been geologically examined in any detail, our information in connection with its various formations and the mode of occurrence of the ore deposits is extremely meagre.

Alluvial gold was first reported from the district early in 1890, as occurring in a creek flowing over clay slates upon which rest horizontally-bedded limestones.

In describing the mineral resources of the Colony, in the annual report of the Government Geologist for 1890 it is stated that:—

These clay slates dip at a high angle to the North-East. They are intersected in places by small quartz reefs or leaders, in many cases ferruginous, but up to the present none of them have proved to be rich in gold. The capping limestone (dolomite), the underlying shaley sandstone and ironstone beds are probably a Northern and Eastern extension of the Carboniferous and Devonian formations, so largely developed on the Lyons and Gascoyne Rivers, though as yet no fossils have been found by which their age can be definitely fixed. The beds dip at an angle of 20° South, resting unconformably upon the upturned edges of the clay slates (Silurian ?), and from their line of junction many strong springs break out. To the South, these limestones form a flat-topped range or tableland, and completely covering the clay slates, which are not exposed again, even in the gullies and the stream beds, although these are often of great depth.

There cannot be the least doubt that the gold in the gullies has been derived directly from the mineral veins in the clay slates, for it has never been found in those gullies where the slates are absent, as the overlying limestones contain no mineral veins. The mineral veins must be of great antiquity, as they were formed prior to the deposition of the superincumbent Carboniferous and Devonian rocks, for in no case do they extend beyond the line of junction.

It is rather remarkable that there are no conglomerate beds in this district at the junction of these two formations, the limestone for the most part resting directly upon the upturned edges of the clay slates. Should any such conglomerate or detrital deposits be discovered, they should be prospected, as it is highly probable they would prove rich in gold.

The gold on this field is very pure, and free from quartz and ironstone. All the larger pieces were of a flat bar shape, owing to their having been formed between the slate ledges by the slow accumulation of fine gold, which by the gradual accretion, due to the deposition of the minute quantities of gold held in solution by the water, has formed into one piece, taking the shape of the cavity or ledge. The largest nugget yet found weighed about 6lbs., and it is estimated that from 9,000 to 10,000ozs. have been taken from these diggings. The run of gold in the main gully extended for over one mile in length, but most of the gullies North and South, for a distance of about five miles along this line, have proved rich.

Whence this gold was derived it is impossible to say without carefully mapping and prospecting the area, but it is highly probable that it results from slow accumulation from poor quartz and ironstone reefs, though in some cases it may have been washed from older "leads" and conglomerate beds which, if they existed, must have followed the present courses of the creeks, for no trace of such beds are now to be seen. *

Yield of the Ashburton Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1891	*a*	*a*	838 14 10	*a* No detailed records given.
1892	*a*	*a*	0 14 0	Do.
1893	*a*	*a*	467 14 22	Do.
1894	*a*	*a*	285 5 10	Do.
1895	*a*	*a*	540 15 4	Do.
1896	*a*	*a*	669 3 9	Do.
1897	*a*	*b*302 19 0	1,038 3 13	*b* Dollied and specimens.
1898	*a*	*c*500 0 0	449 17 12	*c* Alluvial, dollied and specimens.
1899	*a*	*d*1,659 2 0	239 10 3	*d* Alluvial, dollied and specimens
Total	...	**2,426 13 12**	**4,529 18 11**	

Gascoyne Goldfield.

This goldfield, which embraces an area of about 5,061 square miles, was officially proclaimed on the 25th of June, 1897. The boundaries are thus defined by the authorities :—

Starting from the summit of Mount Palgrave, and extending about South-East by South to a point situate 37 miles from the summit of Mount Bresnahan in direction of Trig. Station K20; then about South-West by South to the said Trig. Station K20; thence about South-West to the summit of Mount Gascoyne; thence about North-West by North to the summit of Mount Agamemnon; thence Northward to the summit of Mount Palgrave, the starting point.

The field, though geographically distinct, has been placed under the charge of the same Warden as the Ashburton.

* Annual General Report for the year 1890, H. P. Woodward, Perth: By Authority, 1891 p. 20.

Very little is known of the geology of the field, but it appears that the staple formation is of granite and crystalline rocks, which are covered in places by almost horizontal tablelands of sandstone shale and limestones, for which a Carboniferous age has been claimed.

Prospecting operations are chiefly confined to the neighbourhood of Bangemall, the official centre of the field, but no details as to the nature and mode of occurrence of the ore deposits are available.

The yield of this goldfield, as can be seen by the official figures appended, is small.

Yield of the Gascoyne Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwt. qrs.	ozs dwts. grs.	ozs. dwts. grs.	
1897	1 7 0	*a*13 11 0	*d*	*a* Includes 6ozs. 15 dwts. dollied and specimens
1898	*d*	*b*13 10 0	*d*	*b* Dollied and specimens
1899	235 7 0	*c*333 15 10	333 1 8	*c* Includes 119ozs. 8dwts. 16grs. alluvial
Total	**236 14 0**	**360 16 10**	**333 1 8**	*d* Details not available.

Peak Hill Goldfield.

The Peak Hill Goldfield, which comprises an area of about 12,194 square miles, was established on the 19th of March, 1897. The authorities define its boundaries as follows:—

The portion of Crown lands bounded by lines starting from an angle in the Northern boundary of the Murchison Goldfield, at the summit of Mount Hale, and extending along the said boundary in an East-South-Easterly direction to another angle at the summit of Mount Russel; thence due North to the North-Easterly corner of the East Murchison Goldfield, latitude being on the 26th parallel of South latitude; thence in a Northerly direction to Trig. Station L15 on Wonyuegunna Hill; thence in a North-Westerly direction to the summit of Mount Bresnahan, between the Angelo River and the Upper Ashburton; thence in a South-Westerly direction to Trig. Station K20 on a peak near the source of the Lyons River; thence still South-Westerly to the summit of Mount Gascoyne; thence South-South-Easterly to the starting point on the summit on Mount Hale.

The goldfield includes within its boundaries the high ground lying at the heads of the Gascoyne and the Murchison Rivers.

At the present time mining operations are chiefly confined to Peak Hill, the official centre, and the Horseshoe Diggings, some miles to the North.

The goldfield was discovered some time about the year 1892.

By far the larger portion of the goldfield upon which mining operations on any scale are carried out consists of undulating country, situated on the lofty plateau drained by the heads of the Murchison and the Gascoyne Rivers.

The country rock of the field consists of banded and in places granular quartzites (with secondary silica), micaceous schists, and banded iron-bearing schists or quartzites ; there are no signs of any intrusive rocks anywhere in the vicinity of Peak Hill itself. The quartzites and iron-bearing schists generally appear as fairly conspicuous ridges, whilst the micaceous beds, owing to their feebler resistance to denuding agencies, form the flat or gently undulated portions of the ground. The quartzites and mica schists are vertical, or are inclined at very high angles, but seem to have no prevailing strike. From an examination of the outcrops of the various quartz schists, it is quite evident that a good deal of earth movement must have occurred since the beds were first laid down, and before they were brought into their present position. This is further emphasised by an inspection of the sections exposed below ground in the mine workings.

A remarkable feature in the surface geology of the goldfield are the masses, veins, or dykes of pure silica ; in a few places there, veins have the appearance of massive quartzite, but their mode of occurrence, at angles transverse to the strike of the adjacent strata, confutes this view ; further confirmation is to be found in the fact that in one of the mines a vein of this character is seen cutting across an auriferous quartz reef, and that one of the most noteworthy masses bifurcates after the usual manner of igneous dykes.

The majority of the quartz dykes trend North-East and South-West, and preserve rude parallelism, which, however, is only observable when their position is laid down on a map. In isolated cases there can also be observed another set of quartz dykes roughly at right angles to those last described. The quartz veins are generally inclined at high angles, but not far from the vertical. So far as experience has already gone, it would not appear that these quartz dykes, although auriferous, have proved to be so remuneratively. One of the most significant features in the geological structure of the field is the fact that the richest portion thereof is that which is least intersected by the large quartz dykes.

Somewhat similar in their mode of occurrence are those large masses and dykes of hydrated oxide of iron which are such a conspicuous feature in some portions of the field.

Resting upon the underlying rocks of the field is a variable thickness of recent superficial deposits. These consist of loose gravel or loam, from which gold is obtained by the usual method of dry-blowing. There is, unfortunately, no record as to what amount of gold has been obtained from this loose material, unless it is represented by the 3,349ozs. recorded in 1895.

This gravel reposes directly upon an irregular surface of an ironstained cement. This cement rests upon an old eroded watercourse, and fills up all the inequalities in the latter, which, however, are of no great depth. On the surface of the cement are several large pot-holes, which owe their present form to the gyratory movement of the gravel swept down by the water which flowed down the old channel. In some cases erosion has succeeded in cutting down the cement to bed rock, and exposing the underlying schists. Lithologically the cement is an ordinary conglomerate, formed by the mechanical action of water, and deposited in an old creek bed; its pebbles were derived from the disintegration and subsequent deposition of the pre-existing rocks. The pebbles are embedded in a matrix of sand, formed of the comminuted remains of the underlying rocks. The component parts of the cement are in every way identical with those of the rocks at present outcropping, whilst the number of quartz pebbles are similar in character to the quartz forming those reefs by which the country rock is traversed.

The gold in the cement is not exclusively in grains, scales, or nuggets, but is also found attached to its original quartz matrix. The amount of gold won from the cement has been considerable; the official returns demonstrate that. Up to 1897 1,964 tons of cement crushed have yielded 2,105ozs. 7dwts. of gold, or at the rate of 1oz. 10grs. per ton. Whether the 3,349ozs. of gold returned from an unknown tonnage of quartz has been obtained from the cement or from the superincumbent loose gravel, the official data afford no clue.

In the mode of occurrence the ore bodies, apart from the cement, may be described as a mass of country rock traversed by a network of interlacing veins of auriferous quartz. The mass of country rock is weathered in the direction of kaolin, and possesses, unless in exceptional cases, no sharply defined limits. The gold is not confined to the reefs or veins, but is disseminated through the decomposed country rock.

So far as mining operations have at present been carried, it seems that the richest portions of the fields are those which have undergone the greatest amount of earth movement.

The Horseshoe Diggings are situated on the North-East flank of that sigmoidal-shaped range, of which Mount Beasley forms the highest summit. The Horseshoe Range has a general North and South trend, and is virtually continuous with that low line of hills which extend as far as the township of Peak Hill.

The Range is composed of hematite-bearing quartzites, which dip at a high angle to the West. The outcrop of the iron-bearing series forms the most conspicuous feature of the range, and is visible for great distances. The individual beds are in places minutely puckered and contorted. At the actual summit of Mount Beasley the dip of the iron-bearing quartzite is to the South, at an

angle of 40 degrees. The flats to the North are underlaid by micaceous schists, which readily lend themselves to the action of the weather, and in consequence never form any conspicuous feature in the landscape. The Northern face of the range is drained by several gullies, the most important of which is Nuggety, Prospectors', and Webb's. From the former £16,000 worth of gold is reported to have been obtained by dry-blowing. The area already worked over by the dry-blower is comparatively small, and considering the results which have been obtained, and the abnormally high returns obtained from some of the ore bodies already worked, there are good grounds for a system of judicious prospecting over the creeks and flats yet untried. There are no data by which the yield of gold obtained by the dry-blowers can be deduced.

The following table shows the yield of the Peak Hill Goldfield:—

Yield of the Peak Hill Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	a. Included in the Murchison Export Return.
1894	33	10	0	898	14	20		a		b. Includes 3,349ozs. 8dwts. 23grs. from unknown tonnage.
1895	197	16	0	b 5,749	14	7		a		c. Includes 399ozs. dollied and specimens.
1896	1,712	2	0	4,422	0	0		a		d. Includes 368ozs. 16 dwts. dollied and specimens.
1897	2,992	6	0	c 10,174	19	3	5,110	0	0	e Includes 478ozs. 18 dwts. dollied and specimens.
1898	4,018	1	0	d 14,969	6	12	13,736	17	1	
1899	10,922	0	0	e 31,953	13	0	15,721	6	17	
Total	**19,875**	**15**	**3**	**68,968**	**11**	**18**	**34,568**	**3**	**18**	

Murchison Goldfield.

The Murchison Goldfield, as originally constituted, was first proclaimed on the 24th of September, 1891; its boundaries were modified on the 15th of February, 1895, so as to embrace an area of about 21,000 square miles. As defined by the authorities, the goldfield is:—

Bounded by lines starting from the summit of Mount Murchison, and extending North-Eastward to the summit of Mount Hale; thence East-South-Eastward to the summit of Mount Russel; thence South-Westward to the North-West corner of the Yilgarn Goldfield; thence West-North-Westward to the summit of Wyemandoo Hill, and onwards to Trig. Station K6, on Goonamondey Peak; thence North-Westward to the summit of Mount Farmer; and onwards to the summit of Mount Luke, and onwards to the summit of Mount Murchison.

The geology of the Murchison Goldfield has been investigated by nearly the whole of the geologists employed by the Government, as well as by private observers, hence our knowledge of the broad structural features is perhaps more complete than that of any other of the goldfields of the Colony.

There are four formations, according to Mr. Woodward, exposed on the Murchison Goldfield, viz. :—

Recent.—The alluvium of the water-courses, flats, and salt marshes, travertin, and other surface deposits.

Mesozoic.—Desert sandstone, horizontally-bedded sandstones, clay, pipeclay, gypsum, and ferruginous beds.

Metamorphic.—Slate, schists, quartzite, sandstones mostly ferruginous limestone or granite.

Plutonic.—Granite, diorite, and other dykes.

The recent formations are always of very limited thickness, rarely, as far as yet tested, exceeding 15 to 20 feet. . . . . The Mesozoic (?) formation, if represented by the remains of the old tableland, can be seen well in many cliff sections, but up to the present time no organic remains have been found in them; but to judge from the associated gypsum and iron beds it is highly probable that some will yet be met with. . . . . . It is very strange that no gold has been found in this formation, although it rests directly on the gold-bearing rocks and capping hills at the base of which rich reefs have been found. That gold will be found in rich deposits at the junction of these two formations one would naturally expect, as the auriferous reefs must have been infilled prior to the deposition of the more modern formation, otherwise we should have had the fissure continued on up from one into the other, but this is never the case. . . . . The Metamorphic rocks outcrop, rising as low ridges wherever the overlying desert sandstone tableland has been removed; they are mostly hard, large quartz reefs, often forming the main axes of the ridges, but more generally beds of highly-altered ferruginous quartzite, nearly approaching a mineral vein in character, at the intersection of which the quartz reefs are always richest.

Along the principal belt of auriferous country, the rocks for the most part strike a little to the Westward of North, and underlie to the Westward, consisting largely of talcose and granitic rocks, although hornblende and micaceous slates are also met with. Where there are patches of limestone the surface is covered by travertin deposits and the veins are mostly of a ferruginous calcite, in some of which gold has also been found.

The rocks at the North end of the field take a sudden turn to the North-East and East. Dykes are met with in many places; these are generally either granite or diorite, the latter being of great variety, whilst the former generally contain crystals of foliated talc in cavities.

The mineral veins consist mostly of quartz, but ferruginous lodes and veins of calcite and dolomite also exist. The quartz is of great variety, from pure white, with talc in the granite country, to white, blue, and highly mineralised in other places, whilst the dolomites and calcites are mostly ferruginous.

Where the reefs have been opened up to the water-level many of them contain galena as well as iron pyrites, and veins seem for the most part, as far as one can judge at present, to be true fissure veins, most of them probably continuing in depth; but they will vary greatly in size, direction, and thickness, and many will have to be traced by a mere line or face for a considerable distance. The veins rarely follow the strike or dip of the other rock, but cut across them in all directions, and when they are lost at the ends they generally seem to turn and strike along the line of bedding of the rocks as a mere thread, for some times a considerable distance, making again into a large body of stone, when they strike off more or less on their old course.

The reefs are found to be very rich in shoots, the gold being mostly met with at the intersection of certain beds, whilst at other places either

large bodies of stone or pinches are accountable to the same cause. The question as to which are the true veins cannot be decided until a more systematic survey of the fields has been made, but in most cases where there is a large main line of reef parallel lines are met with, which it is impossible to trace for any distance; these latter are in all probability not true veins, but only in-filled lateral fissures, which, although often very rich, will not extend for any distance along the surface or in depth.

The main lines of reef seem to follow a more or less North and South course, but there are some very rich ones which strike East and West; these also vary greatly, some being small cross-courses, extremely rich at their intersection with main North and South reefs, and others, such as the Star of the East, which seems of quite a different character to anything else on the field, but which still present all the characteristics of a fine lode of a very broken character, but from the nature of the stone this must be expected until sinking is carried into the solid country. The ferruginous reefs are met with mostly at Quin's. Many of these will prove to carry a very great deal of pyrites in depth, but, as a rule, the reefs on this field are exceptionally free from any objectionable mineral.*

According to Dr. Schmeisser, a considerable area of quartz diorite, of granitic habit, occupies that portion of the Murchison goldfield in the vicinity of Cue, and forms the matrix of the numerous quartz reefs which trend and underlie in all directions. The coarse diorite is decomposed to a depth of about 100 feet in the direction of kaolin, which is of a white but more rarely of a brown colour. The undecomposed quartz diorite appears to approach tonalite in its mineralogical composition.†

For administrative purposes the Murchison Goldfield has been divided into four districts, viz., Nannine, Cue, Day Dawn, and Mount Magnet.

The following figures show the yield of the Murchison Goldfield, since its inception:—

Yield of the Murchison Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1891							2,064	8	16	*a*. Details not available.
1892							24,356	9	12	*b*. Includes 1,400ozs. 13dwts. 12grs. dollied and specimens.
1893							21,210	8	22	
1894	*a*110,805	0	0	*a*140,432	5	15	52,946	6	11	
1895							65,477	5	3	*c*. Includes 1,119ozs. 2dwts. 10grs. dollied and specimens.
1896							71,282	13	17	
1897	72,003	16	0	*b* 62,316	3	21	82,891	17	1	
1898	92,255	16	0	*c* 79,256	7	20	93,667	3	6	*d*. Includes 214ozs. 2dwts. 15grs. alluvial, and 2,844ozs. 9dwts. 22grs. dollied and specimens.
1899	66,986	17	2	*d* 81,086	5	13	68,842	7	17	
Total	**342,051**	**9**	**2**	**363,091**	**2**	**21**	**482,739**	**0**	**9**	

East Murchison Goldfield.

The East Murchison Goldfield was originally proclaimed in May, 1895, but, for administrative purposes, its boundaries were so

* The Murchison Goldfield. H. P. Woodward, Perth: By Authority, 1893; pp. 9-11.
† Die Goldfelder Australiens. Karl Schmeisser, Berlin, 1897; p. 58.

altered in December 1897 as to embrace an area of about 28,242 square miles, which is thus defined by the authorities :—

Bounded by lines starting from the Southernmost corner of the Murchison Goldfield, situate about four and a-half miles East, and four miles South from Trig. Station K75, on Wyemandoo Hill, and extending East to a spot about 15 miles East, and about 44 miles North from the summit of Mount Ida ; thence North about four and a-half miles ; thence East about 74¼ miles, passing through a tree marked A.N. 33 at Doyle's Well, to a spot about 2 miles 10 chains West, and about 35½ miles North from a tree marked 1,382 at Brickey's Soak ; thence North to the 26th parallel South latitude ; thence West to a spot due North of the summit of Mount Russel ; thence South to the said summit of Mount Russel ; thence South-South-Westward along the Eastward boundary of the Murchison Goldfield to its Southernmost corner, the starting point.

Not very much is known geologically of the East Murchison Goldfield, no detailed examination having been made on the district by any member of the Geological Survey Staff. A report by Mr. F. Reed, * and another by Mr. Torrington Blatchford, † are about the only official data extant.

From the former author's description, it appears that the country consists of foliated granite gneiss, massive and banded diorites, covered with "desert sandstone" and deposits derived from the disintegration of these rocks.

The observations of Mr. Blatchford in the East Murchison Goldfield have shown that granite is the staple formation, which has been invaded by dykes and masses of some basic rock, together with a much later series of intrusions of acidic rocks, which usually form narrow tortuous dykes. Near the junction of the basic rocks and the granite a strong development of hornblende, mica, and iron-bearing quartz schists are of frequent occurrence. These schists are seen to pass gradually into granite in such a way as to suggest that they may be merely highly metamorphosed forms of the latter. These crystalline rocks are covered by sandstones, quasi-vitreous sandstones, and conglomerates, which have been classed, inferentially, as of Mesozoic age. Of a much newer date than these are the deposits of ironstone gravel which cover such an extensive area of country. The origin of these, however, is not quite understood. Their largest development, however, occurs to the West of the Montague Range, which is made up of iron-bearing quartz schists so prevalent in the Mt. Hale district.

There are four principal mining centres on the East Murchison field, viz., Lawlers, Lake Darlôt, Mount Sir Samuel, and Lake Way.

At Lawlers, the reefs are said "‡to occur along the zone of contact between the gneissic granite and diorite schists." The reefs

* The Geological Features and State of Mining in the Lawlers and Mount Sir Samuel Districts. F. Reed. Report of the Department of Mines for the year 1896. Perth: By Authority, 1897 ; pp. 33-35.

† A Geological Reconnaissance of the Country at the heads of the Murchison and Sandford Rivers, in the Murchison and Peak Hill Goldfields. T. Blatchford. Annual Report of the Geological Survey for the year 1898. Perth: By Authority, 1899 ; pp. 36-50.

‡ F Reed. *Loc. Cit.*

have a general East and West trend, and can be followed along the surface for considerable distances.

The Mount Sir Samuel mining centre is situated at the Southern end of the Violet Range, immediately to the North of Lake Miranda. Stretching from Lake Miranda Northwards, the Violet Range extends as far as the Jones Creek ; and consists of a succession of semi-detached hills, the culminating point being Mount Goode, which rises to an altitude of 350 feet above the surrounding country. Geologically, this Range is a diorite boss, occurring in massive granite, of a similar nature to the granite at Lake Way. . . . . . Breaking through the diorite boss, usually in an East and West direction, are numerous granite dykes of apparently a later age. These dykes vary in thickness from a few inches to several feet. They are particularly conspicuous on the sides of Mount Goode, where they can be traced for considerable distances. In close association with these dykes are some very large quartz reefs, which latter, as far as surface indications show, follow the strike of the dykes with great persistency.

At McDonough's Lookout, another apparently disconnected diorite boss is found, with numerous granite dykes intruding, and the associated quartz reefs. The granite dykes in this locality are coarse-grained, and can clearly be seen to consist of quartz, orthoclase felspar, and mica. The mica, however, occurs in two forms, the Muscovite (common white mica), and Lepidolite (lithia mica).

The quartz reefs at McDonough's Lookout are of the white opaque barren variety, and will scarcely recommend themselves to prospectors. Included in the quartz are large irregular mangane-ferruginous nodules in considerable quantity. . . . . In addition to the reefs associated with the granite dykes, other quartz reefs are found in the massive diorite. These latter, for the most part, though sometimes rich in gold, are lenticular, and too expensive to work or prospect for in the hard diorite rock. Besides the quartz reefs, there is one example of a fissure lode being worked, viz., at the Belle Vue Mine. *

The following figures show the crushings and the yield of gold since the date of opening of the goldfield :—

Yield of the East Murchison Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1896	1,467 0 0	*a* 2,576 0 0	...	*a* Previous to 1896 the returns were included in the Murchison Field, *vide ante*.
1897	11,763 0 0	*b* 20,995 1 7	9,453 16 6	*b* Includes 443ozs. 3dwts. 8grs. dollied and specimens 621ozs. 3dwts. 16grs. of alluvial.
1898	31,947 19 3	*c* 37,080 6 10	39,563 7 0	*c* Includes 641ozs. 2dwts. 19grs. alluvial, and 1,115ozs. 5dwts. 6grs. dollied and specimens.
1899	42,166 15 0	*d* 45,038 18 5	37,811 11 19	*d* Includes 1,628ozs. 4dwts. 9grs. alluvial, and 1,485 ozs. 7dwts. 17grs. dollied and specimens.
Total	**87,344 14 3**	**105,690 5 22**	**86,828 15 1**	

* T. Blatchford. *Loc. Cit.*

CHAPTER III.

GOLD (*continued*).

MOUNT MARGARET, YALGOO, NORTH COOLGARDIE, YILGARN, COOLGARDIE, BROAD ARROW, EAST COOLGARDIE, NORTH-EAST COOLGARDIE, DUNDAS, DONNYBROOK.

MOUNT MARGARET GOLDFIELD.

This Goldfield, which was previously included in the North Coolgardie Field, was originally proclaimed on the 10th of March, 1897, but its boundaries were amended on the 24th of December, 1897, so as to embrace an area of about 42,154 square miles.

The boundaries, as defined by the authorities, are as follows:—

Bounded by lines starting from a spot about 15 miles East and about 13 miles North from the summit of Mount Ida, and extending North about 25½ miles; thence East about 74¼ miles, passing through a tree marked AN 33 at Doyle's Well, to a spot about 2 miles 10 chains West and about 35½ miles North from a tree marked B 82 at Brickey's Soak; thence North to the 26th parallel of South latitude; thence East to the 125th meridian East longitude, and South along that meridian to a spot due East of said tree marked B 82 at Brickey's Soak; thence West through the said tree to the starting point.

The Mount Margaret Field, which bids fair to rise to some prominence as a gold producer, has never been the subject of an official geological report, hence our knowledge of the mode of occurrence and association of the ore bodies is somewhat meagre.

A very large portion of the surface of the ground is covered with a variable thickness of recent accumulations, derived from the disintegration of the underlying rocks.

The staple formation is granite, granitic gneiss, schists, and quartzites intersected by basic volcanic rocks.

The schists are often vertical, or inclined at high angles, and are traversed with quartz reefs, many fragments of which are strewn over the surface.

Some of the quartzites stand up in bold relief, and can be traced by the eye for some miles across country.

It is associated with one of these bands of quartzite that the ore body in the West Australian Mount Morgan occurs. This quartzite is impregnated with oxide of iron in places, while at others it is very spongy and sintery. The Sons of Gwalia Mine is another, in which the ore body is associated with quartzite or quartz schist.

The mode of occurrence of some of the lodes on the Mount Margaret Goldfield bears a close resemblance to those on the East Coolgardie Field.

The following table shows the yield of the Mount Margaret Field since its inception up to the end of 1898:—

Yield of the Mount Margaret Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwts. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	*a*. Previous to 1897 included in North Coolgardie Return.
1895 } 1896 }	231 0 0	*b* 4,992 2 2	*a*	*b*. Includes 300ozs. dollied and specimens.
1897	13,198 14 3	*c* 22,592 1 19	8,685 14 14	*c*. Includes 2,018ozs. 5dwts. dollied and specimens and 588ozs. 16dwts. 20 grains alluvial.
1898	37,506 13 2	*d* 49,717 15 9	43,266 13 20	*d*. Includes 387ozs. 13dwts. 16grs. dollied and specimens, and 675ozs. 4dwts. 22grs. alluvial.
1899	75,713 17 0	*e* 80,123 12 0	64,905 10 12	*e*. Includes 601ozs. 3dwts. 15grs. dollied and specimens, and 345ozs. 4dwts. 18grs. alluvial.
Total	**126,650 5 1**	**157,425 11 6**	**116,857 18 22**	

Yalgoo Goldfield.

The Yalgoo Goldfield was originally proclaimed in February, 1895. Its boundaries, which enclose an area of about 18,921 square miles, are thus defined by the authorities:—

Starting from the summit of Mount Murchison, and extending West-South-Westerly to the summit of Tallering Peak; thence South-Easterly to the summit of Mugga Mugga Hill, and onwards to the summit of Mount Gibson, which lies about 12 miles South-West from Ningham Creek; thence Eastward to Trig. Station K 83, on the West shore of Lake Moore; thence due East to the Western boundary of the North Coolgardie Goldfield, and along it North to its North-West corner; thence North-Westward to the summit of Wyemandoo Hill, and onwards to Trig. Station K 6, on Goonahmondey Peak; thence North-Westward to the summit of Mount Farmer, and onwards to the summit of Mount Luke, and onwards to the summit of Mount Murchison.

Gold was first discovered upon this field in the early part of 1890, at the Nancarrong Hills, which are situated a few miles to the Eastward of Yewin Station, which is about 100 miles North-East of Geraldton and 150 miles South-West of Cue. The gold was found in a large reef of bluish glassy quartz stained with copper, which strikes East and West, and apparently dips at a high angle to the North. The rocks are quartzite and mica slate, with granite dykes and ironstone lodes, which follow the same strike of the reef.*

The same author, writing in 1896, says that the field:—

Is situated upon the high ground immediately behind the range which ses at the head of the Irwin River. It is drained by the Murchison and

* The Yalgoo Goldfield. H. P. Woodward. Mining Handbook to the Colony of Western Australia. Perth: By Authority, 1895; p. 90.

Greenough Rivers, whilst to the Southward all the streams discharge themselves into Lake Monger; of these the Greenough River drains much the largest area; in fact this goldfield may be said to be situated upon the upper courses of that river. The surface is broken and hilly, small stony sides or granite hills rising abruptly from alluvial flats.

The principal centres of the field are Yalgoo, Melville, Gullewa, Pinyalling, Woodley's, Damperrah, and Nancarrong.

Yalgoo, which is the official centre, is situated upon the Cue railway. The reefs occur in a broken belt of schistose country, the strike of which is East and West, whilst the diorite dykes and lodes follow the same lines. Many of these veins were extremely rich, particularly one called the Emerald, where a very showy deposit was discovered, but which, when the company that had purchased it started to work, proved to be, instead of the cap of a lode, a small almost flat reef, with no defined formation and of no extent. Several of the other lodes here are nothing more or less than lenticular bunches of quartz . . . . *

The following table shows the yield of the Yalgoo Goldfield as prepared from official data :—

Yield of the Yalgoo Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwts. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1895 } 1896 }	a2,488 0 0	a 7,227 0 0	b	a. Details not available. b. Previous to April, 1897, included with Murchison.
1897	3,666 19 1	3,455 15 21	2,034 4 15	
1898	4,424 10 0	3,298 18 21	3,756 7 16	
1899	17,933 10 1	c 12,135 18 20	5,689 10 15	c. Includes 16ozs. 10dwts. dollied and specimens.
Total	28,512 19 2	26,117 13 14	11,480 2 22	

North Coolgardie Goldfield.

This goldfield embraces an area of 30,609 square miles, and, according to the authorities, is circumscribed :—

By lines starting from the Southernmost corner of the Murchison Goldfield, being the South-West corner of the East Murchison Goldfield, and situate about 12 miles East and five miles South from Trig. Station K 75 on Wyemando Hill, and extending South to the South-East corner of the Yalgoo Goldfield, which is a point due East from Mount Gibson, near Lake Moore, and due North of a spot 10 miles West of a cairn on Yorkrakine Granite Rock; thence East-South-East to a point about 50 miles due West from a cairn marked NB 1, near Wangine Soak; thence East to Survey Station NB 1.; thence about 87° 20 miles 22 chains to Survey Station R 3; thence East to the 125th meridian East longitude; thence North along that meridian to a point East of a tree marked B 82 at Brickey's Soak; thence West through the said tree to a spot about 76¼ miles West from it, and 13 miles North and 15 miles East from the summit of Mount Ida; thence North about 31 miles to the South boundary of the East Murchison Goldfield, and West to the starting point.

* The Yalgoo Goldfield. H. P. Woodward. Annual Report of the Department of Mines for the year 1895. Perth: By Authority, 1896; pp. 21-22.

This field, which originally formed part of Coolgardie, has, for purposes of administration, been subdivided into the Menzies, Ularring, Niagara, and Yerilla districts.

In its topographical features, Menzies is very hilly, the ground ranging from 1,330 to 1,660 feet above sea-level. The most prominent feature in the district is a more or less continuous ridge on the East, trending approximately North-West and South-East, and from which spurs radiate towards the West. The area over which most of the productive mines are situated lies at the foot of the main ridge, though at some considerable distance to the Westward.

In its geological structure, the field presents feature which connect it geologically with those of Kalgoorlie and Coolgardie. The country rocks of Menzies consist of granite, gneiss, hornblende, mica, sericite, and serpentinous schists, associated with amphibolites, ferruginous quartzite, and diorite dykes. Felsite dykes have been noticed in some parts of the district. Ferruginous conglomerate, passing in places into pure limonite, occupies the caps of certain of the hills. All the rocks have suffered a considerable amount of decomposition, which extends to a depth of about 100 feet from the surface.

The lodes of Menzies, which are of a more or less schistose habit, have an approximate parallelism; they trend generally North-West, and have a fairly high underlie to the West. The gold occurs associated with iron, copper, and arsenical pyrites, galena (which is very abundant), and zincblende. Free gold occurs in the rocks within the zone of oxidation.

No geological examination of the other districts having been made, no details in connection with the ore deposits are available.

The table shows the yield of the North Coolgardie Field :—

Yield of the North Coolgardie Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwts. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1896	*a* 13,414 10 0	*b* 26,577 15 10	*c* 17,160 10 4	*a.* Complete details not available. *b.* Complete details not available, but includes 275ozs. from unknown tons.
1897	33,691 15 0	*d* 61,747 18 3	74,556 2 12	*c.* Included with Coolgardie prior to 1st May, 1896.
1898	42,032 15 3	*e* 72,878 17 12	70,625 6 4	*d.* Includes 391ozs. 2 dwts. 12grs. of dollied and specimens, and 120ozs. of alluvial.
1899	93,376 5 0	*f* 117,138 5 4	60,909 7 16	*e.* Includes 924ozs. dwts. 8grs. of dollied and specimens. *f.* Includes 1,118ozs. 6 dwts. 19grs. of dollied and specimens, and 796ozs. 15dwts. 13grs. of alluvial.
Total	**182,515 5 3**	**278,342 16 5**	**223,251 6 12**	

Yilgarn Goldfield.

The Yilgarn field, as officially declared, embraces an area of 15,593 square miles:—

Bounded by lines starting from a point 90 miles South of a cairn, H 26, on Koorarawalye Granite Rock, and extending West to a point due South of a point 10 miles West of a cairn on Yorkrakine Granite Rock; thence North to the South-East corner of the Yalgoo Goldfield; thence East-South-East to a point about 50 miles due West from a cairn marked NB (conjoined) 1, near Wangine Soak; thence South through the before-mentioned cairn H 26 to the starting point.

The occurrence of gold in what is now the Yilgarn Goldfield would seem to have been made known by Mr. Glass, of Mugakine, in the year 1887.

According to H. P. Woodward:—

The Yilgarn Hills are a low range of hills about 250 miles East of Perth, and are on the Western side of a series of salt lakes, of which Lake Deborah is the Southernmost one. They are from two to three miles in width East and West, whilst the general direction of the range is from North and South. The Western face is somewhat steeper than the Eastern, which gradually descends towards the lakes, from which it is separated by a plain, of from four to six miles in width, of red clay strewn with ironstone and quartz. The rocks are mica schist, mica slate, and shaly quartzites, with many diorite dykes and quartz veins. Their general strike is North and South, with an Easterly dip. They have been tilted up from the West by a large mass of intrusive granite, which forms a rough Western face to the hills in the Northern part; but to the South it is only seen appearing above the surface of the plain in large rounded masses. The quartz reefs follow the strike of the rocks, but vary greatly in character, the white quartz being, as a rule, not in such large masses or so well defined as the more ferruginous ones.

The same author notes that the quartz reefs of the granite:—

Are either white quartz containing some pyrites, but not well defined, large yellow jaspery reefs, or large blue and ferruginous banded quartz veins, with some hematite, but not of a very promising appearance; whilst in the slate country to the East they are more lenticular masses of white quartz with ironstone, some of which can be traced for a good distance, but mostly only a few feet; but these veins have a far more promising appearance than those in the granite. The most Northern portion of the field is called Golden Valley, the mines being situated in a small valley which runs North and South. The rocks here are very hard hornblende schists, with small quartz reefs and large ferruginous and jaspery quartz dykes, the former of which carry gold. The quartz is of a granular character, often almost approaching a sandstone, and contains, in places, large quantities of iron pyrites, whilst some of the small rich offshoots contain a great deal of copper pyrites. The lodes which have proved auriferous form three lines, the Eastern and Western being both small and poor in gold, and, to judge from the formation, are probably legs or branches of the same lode, as the country here forms a sharp anticlinal fold, the junction cap having been denuded. These reefs contain little mineral, and the gold is in a very fine state through the stone, but they are rather small in size to pay. The other line was discovered between these two at the centre of the valley, and did not outcrop at the surface at all. It was immensely rich at the cap, which consisted mostly of gossan, often copper-stained. This reef splits in two, one branch dipping West and one East. The Eastern one seems the best formed, and has been opened up to a considerable depth, where it consists of white quartz with pyrites, whilst in the country between the two branches there are numerous leaders containing a great deal of copper pyrites rich in gold,

The Eastern branch has been followed for a considerable depth, and proved very rich, showing gold freely all the way down; but it takes a most irregular course, turning and twisting about, and apparently cutting out in places only to make again into a larger mass of stone.

Hope's Hill is about 30 miles South of Golden Valley; the lode here forming the main ridge of the country running North and South, and gradually rising from the lake level at the South end to about 200 feet above it at the North end. The quartz on the main hill is of a white hungry-looking character, but carrying fine gold in the stone and clay partings, particularly on the East side of this reef, in a white magnesian clay full of quartz grit. On this side of the reef there is a mass of whitey-brown and greenish-blue banded clay, probably resulting from the decomposition of a serpentine rock, full of small quartz leaders, of a curious gritty nature. These leaders are, as a rule, rich in gold, and in some parts gold is also met with along the joints of the clay, but for the most part it is not visible, though, on crushing, good results are obtained. The bulk of the reef is a white stone of barren appearance, though here and there are bands containing iron, which yield, on crushing, very good prospects of gold. The reef, which is about fifty feet wide at the surface, seems to be in reality a series of reefs separated by partings or casings of a white greasy clay.

The richest stone is found in the mass of leaders to the East of the reef; but the main portion is useful for crushing with the mullocky portion. To the Southward this reef decreases in size, but there, still, the same size patches of stone are met with, but the clay becomes more solid, and presents more the appearance of a decomposed dyke of a greenish tinge; the gold often being met with on the faces like thin paint. There is an enormous lode formation, with shoots of stone first on one side of the lode then on the other; these, had they been picked, would have yielded good returns, but as it was considered more economical to crush the whole of the lode stuff taken out, the crushings have been low, but this system will cease when the work of development is complete. No water has yet been struck in the mine, as the water level is some 100 feet below the level now being driven into the hill. This reef, owing to the fact that it rises up out of the plain, could be easily and cheaply worked, and considering the great mass of stone which carries gold, it would pay well to work on a large scale.

Near the lake there are some pyrites lodes which contain a good deal of gold.

Southern Cross is situated about thirty-five miles to the South of Golden Valley. There is here a series of reefs running more or less North and South, which appear to have been formed at different periods; but without carefully mapping this district, when it has been sufficiently opened out, it is impossible to express a certain opinion on this point; for the present it is enough to say that there are three lines of true lodes, one white, one ferruginous, and one mullocky with quartz leaders, and one series of cross-courses.

These true lodes apparently owe their origin to the great upheaval which has taken place on the Eastern and Western sides of this area, to which they run parallel, while the cross courses are due to a later intrusion of granite, masses of which stand out as bold, bare, isolated hills.

The country is of comparatively slight elevation, consisting of low, thickly timbered hills, flats, and claypans, or lakes, the reefs for the most part appearing on the low ridges, but in some cases they were also visible on the edges of the lakes. The rocks are chiefly hornblende schists, but micaceous, chloritic, and talcose schists also occur, while both to the East and West metamorphic and intrusive granites appear, and occasionally trap dykes are found.

The Eastern is the main line on which the principal mines are situated. It is of a large size, and the quartz is thoroughly mineralised, but does not contain any minerals which will interfere with the abstraction of the gold.

The general description of the lode mass is a large inter-bedded lode, well formed in the deeper ground, between two good walls, striking a little to the West of North, and dipping at an angle of about 80 degrees to the Westward.

This mass varies in width from 5ft. to 30ft., but it rarely consists entirely of stone, especially in the larger portions, where a series of lenticular masses of quartz are met with, the rest of the lode being composed of broken country intermixed with smaller veins and leaders of quartz.

These quartz masses often extend along the line of reef for 100ft., and are generally the richest portion of the lode, and are sometimes met with on one wall and sometimes on the other. The stone is of a highly mineralised character, containing a small quantity of galena, pyrites, and chlorite, the latter often giving the stone a greenish appearance. These reefs are often a good deal iron-stained at the surface, with red clay partings and walls, the foot wall being well formed, whilst there is, at the upper part of the lode, no hanging wall; but the reef splits up into numerous veins and leaders, which strike away into the country.

The rich portions run in well-defined shoots, but it is also rich enough in gold throughout the reef to pay if worked on a large scale.

At the Northern end of this line the reef seems to split into two branches. In the Eastern one there is a great deal of serpentine, which is often very rich in gold.

The stone from this line, when crushed, has always averaged 1oz. to the ton of stone, so they have proved so far payable. The ferruginous line contains a large quantity of jasper, and some very rich specimens were found at the surface, but nothing much has yet been done to test this line in depth.

The Western line is evidently a decomposed dyke, and in one place contained some very rich stone in patches for a considerable depth, but little has been done on it yet.

There is another rich reef, about 15 miles South of Jacoletti's, on a small range (Parker's Range) of schistose rocks to the Western side of a large salt swamp or claypan. There are several lines of reef; but most of the claims have been taken up on one which runs in a North and South direction, dipping to the West.

These reefs contain more pyrites than those at the Southern Cross; but this is only seen below the water level, for near the surface it is decomposed, thus liberating the gold, which shows freely in the stone.

About five miles South there are another series of reefs, which are as a rule small but well defined, carrying rich shoots or patches of gold. At Parker's Range the reef again dips West in pretty firm country, the stone containing a great deal of iron pyrites (mundic), which will carry the gold in depth.

The whole Yilgarn field seems to follow one anticlinal fold in the country, the centre of which is exposed at Golden Valley, where the reefs dip both East and West, where the country is hard and the stone carries much copper.

Hope's Hill and Southern Cross are on the Western side of this fold, whilst Blackborne's is on the other side of a synclinal still further West, where the reefs dip to the East. All along this line of country the stone is highly mineralised, containing carbonate of iron and chlorite.*

* **H. P. Woodward. Mining Handbook,** ***Loc. Cit.***

The following table gives the yield of the Yilgarn Goldfield :—

Yield of the Yilgarn Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1889			1,858 10 0	
1890			2,277 0 0	
1891			12,833 5 23	a. Details not available.
1892			21,209 9 18	
1893	a 174,925 0 0	b 94,194 11 21	75,744 10 23	b. Details not available, but includes 738ozs. 3dwts. 12grs. of dollied and specimens.
1894			31,498 7 17	
1895			19,747 15 2	
1896			16,565 5 0	
1897	35,988 0 0	17,072 16 12	17,994 9 13	
1898	27,807 7 0	11,769 8 1	11,696 3 13	
1899	33,403 3 2	16,371 15 13	7,734 6 21	
Total	**272,123 10 2**	**139,408 11 23**	**219,159 4 10**	

Coolgardie Goldfield.

The Coolgardie Goldfield embraces an area of 11,974 square miles, and is defined by the authorities as being :—

Bounded by lines starting from the North-East corner of the Yilgarn Goldfield (which is a point about 50 miles West from a cairn marked N B1, near Wangine Soak), and extending South about 118 miles through a cairn H26 on Koorarawalye Granite Rock ; thence East about 133 miles through the summit of a granite rock near the 50-Mile Soak, on the Dundas and Lake Lefroy Road ; thence North about 48 miles to a point 35 miles East of the South-East corner of Hampton Plains Location 48; thence West 35 miles to the South-East corner of the above-mentioned Location; thence along the boundaries (surveyed) of Location 48, Westerly 443 chains 91 links, Northerly 564 chains 87 links to the South-East corner of Location 51 ; thence along the boundaries (surveyed) of that Location Westerly 160 chains, Southerly 60 chains, Westerly 119 chains 87 links to the South-West corner of Location 51; thence Northerly 400 chains along the Westerly boundary of Location 51 and the Eastern boundary of Location 53 to the North-East corner of Location 53; thence along a surveyed line 324° 16′ 36 miles 1,481 links ; thence North 30 miles 47 chains 46 links along a surveyed line to a tree R3, near Cane Grass Swamp, on the 90-Mile Road ; thence Westerly about 50 miles to the starting point.

Previous to 20th March, 1896, the Coolgardie Goldfield embraced the present Coolgardie, East Coolgardie, North-East Coolgardie, and Broad Arrow Goldfields, all of which, together with the present Yilgarn field, were originally known as the Yilgarn Goldfield.

Coolgardie Goldfield, as at present constituted, was officially declared on the 20th of March, 1896, and, for purposes of administration, was eventually divided into the Coolgardie and Kunanalling Districts.

Coolgardie.—The area of the mining centre in the vicinity of Coolgardie has been examined in some considerable detail. The geological features of this area are marked by a mass of intrusive granite on the West, succeeded by a belt of hornblende and talcose schists, the whole being intersected by dykes of both basic and acidic rocks. The most extensive area of granite is that which extends from the Coolgardie-Menzies and Coolgardie-Norseman telegraph lines to a point some three or four miles to the Westward; on both sides of this the schistose rocks, which are much contorted and altered, dip away from either side of the granite mass. Further to the South-Westward, and about three miles West of Londonderry, is another granite mass of a somewhat slightly different character. The granite has been penetrated to a depth of 3,000 feet by a diamond drill put down on the Gnarlbine Road, about two miles South-West of the town, on Reserve 3647. The acid eruptive rocks, which, as a rule, follow the strike of the schists, in all probability emanate from the main granite mass, as cases occur in which a gradual passage from the latter can be identified. The dykes seldom exceed twelve feet in thickness. Quartz reefs are often intimately associated with the acidic dykes, and in some cases the latter gradually pass into pure quartz at their extremities. As a rule, these quartz veins are non-auriferous. Certain black or dark banded rocks, of somewhat obscure origin, are invariably found in intimate connection with the felsite dykes. In certain portions of the field they bear a marked resemblance to highly metamorphosed sedimentary beds, to which they may eventually be referred. These black slates (?) exhibit an almost perfect slaty cleavage and texture; they are often elaborately puckered. The banded rocks are not confined to the schists, but appear to traverse the large masses of basic rocks, and intersect the dykes at all angles.

The schistose rocks which are hornblendic, or occasionally talcose, seem to result from the surface weathering of amphibolites. The general strike varies from North 20° West and South 20° East to North 20° East and South 20° West, the dip being from 30° to 60° to the East; more rarely the beds dip West, but such is of local occurrence.

The diorites and andesites form both bosses and dykes, and are found invading both the granite and the schist. So far as observations have been carried it seems that the diorites are of older date than the andesites, as cases occur in which the latter are seen traversing the diorites.

In certain portions of the field, both the granite and schistose rocks are covered with a variable thickness of their own weathered *débris* and other superficial deposits. These superficial deposits extend over a very large portion of Coolgardie; they vary in thickness from a few inches up to several hundreds of feet, as in Rollo's Bore.

Ancient water channels exist in the vicinity of Coolgardie. About eight miles from the township, one of these has been pierced by a bore to a depth of 162 feet. This deposit has been utilised

as a source of the water supplied to Coolgardie by the Hampton Plains Company. The following is a section of the strata pierced:—

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Clay (with ironstone gravel) ...	27	0	...	
Fine sand	30	0	27	0
Coarse yellow (water bearing) ...	...		...	
Sand	43	0	57	0
Clay	4	0	100	0
Sand-wash	11	0	104	0
Kaolin (?)	8	0	115	0
Bed-rock (nature undetermined)...	39	0	123	0
Total ...	**162**	**0**	**162**	**0**

The water struck in this bore rose to some considerable height above the level at which it was first met with.

In some portions of Coolgardie there occurs, resting on the denuded granite surface, a thin bed of cement of the type occurring at Kanowna and the 25-Mile. What now remains of this cement occurs in every case at levels between 1,380 and 1,460 feet above sea level; showing that the deposit has a somewhat uniform altitude. The average thickness of the cement does not exceed 3 feet, and, although auriferous, it has not, up to the present, proved to be payable.

The geological age of the alluvial deposits is somewhat conjectural, as they have, with one or two exceptions, proved to be unfossiliferous. There are reasonable grounds for believing that some, at any rate, are of late Tertiary age.

The gold obtained from Coolgardie has been derived from three principal sources, viz., alluvial deposits, lode formations, and quartz reefs. The gold from the recent superficial deposits presents all the usual characters. Unfortunately there are no data available by which the amount of alluvial gold obtained from the Coolgardie Goldfield can be deduced. The "lode formations," as a rule, consist of schistose rocks traversed by a network of quartz leaders; the formations appear to possess no sharply defined boundaries, unless in exceptional cases; the limits of the deposits being defined by purely technical considerations. A great deal of gold seems to have been derived from these formations; but owing to the way the returns are supplied, it has not been possible to separate the yield of the formations from that of the quartz reefs proper. The quartz reefs trend generally North and South, and have a dip of from 60° to 80° to the East.

Many of the quartz reefs in the neighbourhood of Coolgardie stand up from the surface like walls of masonry, 15 or 20 feet high, having resisted

the denuding action of the atmosphere better than the enclosing country rocks.*

There are two distinct varieties of reefs, one closely resembling the lode formations and occurring in large lenticular patches, often forming pronounced outcrops on the surface, and the other of the true fissure type. Of the first class, the reefs on Bayley's Reward Claim, and the Big Blow Mining Lease, No. 35, are the best examples, whilst Sherlaw's Perseverance, and Burbank's Birthday Gift Mining Lease, No. 3252, are examples of the second class. At the deeper levels the quartz reefs usually carry arsenical and iron pyrites.

The gold is not evenly distributed throughout the reefs but sometimes occurs in irregular patches, one of which, Bayley's, has yielded several thousands of ounces from a very small area. The gold, at times, occurs in shoots, but so far no observations have been recorded as to either their direction or strike.

Kunanalling.—The mining district of Kunanalling (the 25-Mile) has long been noted for its auriferous cement deposits; these have been extensively worked and have proved fairly rich in gold.

The cement at the 25-Mile is of similar character and origin to that at Kanowna. The deposit, which follows a serpentinous course—an old creek—along an eroded granite surface, has been followed for over a mile and a-half; though there are frequent breaks, due in all probability to erosion. The floor upon which the deposits rest is a biotite-granite, which has been much decomposed; the results of erosion are strongly marked by the numerous pot holes and deep gutters. The deposits consist of rounded and sub-angular fragments of quartz of all sizes, cemented together by a ferruginous silicate of alumina in varying proportions. Where the cementing material is not quite so abundant, the grains are usually of a finer or more even texture, having the appearance of a sand-stone so soft as to crumble easily in the hand. In places the cement is overlaid by ironstone gravels which are sometimes separated by a thin layer of pure white kaolin.

The ironstone gravels and kaolin are said to contain small quantities of gold, though not payable. The payable gold, almost without exception, occurs in the cementing material. The richest portions of the deposit have been found where the coarser material was lying on the bottom, and especially where it had gathered on the lower side of some of the larger pot holes.

There seems little doubt that the gold has been deposited mechanically, though a certain quantity may have been added from solution. The ultimate derivation of the gold is from the veins and reefs occurring in the vicinity.

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* The Geology and Mineral Deposits of Portions of Western Australia. E. F. Pitmann. Records Geol. Survey of N.S.W. 1898. Vol. VI. Pt. I., p. 6.

The quantity of gold derived from these deposits, so far as the official returns show, is, up to the end of 1899, as follows:—

Date.	Quantity of Stone Crushed.	Yield of Gold.	
		Total Yield.	Rate per ton.
	tons cwt. qrs.	ozs. dwts. grs.	ozs. dwts. grs.
1897	5,397 0 0	7,363 0 0	1 7 6
1898	3,309 10 0	3,038 18 17	0 18 8
1899	6,962 0 0	3,758 18 4	0 10 19
Totals...	**15,668 10 0**	**14,160 16 21**	**0 18 1**

The following table gives the production of gold from the Coolgardie Goldfield:—

Yield of the Coolgardie Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwt. qrs.	ozs. dwts. grs.	ozs. dwt. grs.	*a*. Details not available.
1894			*b*105,329 16 11	*b*. Included with Yilgarn prior to 5th April, 1894.
1895	*a* 31,419 13 0	*a* 66,691 14 23	125,105 18 18	*c*. Includes 236ozs. 17dwts. of dollied and specimens.
1896			69,135 3 16	*d*. Includes 1,158ozs. 19dwts. 3grs. of dollied and specimens, and 52ozs. 14dwt. 7grs. of alluvial.
1897	56,183 19 1	*c* 72,281 9 22	104,306 7 9	*e*. Includes 1,713ozs. 10dwt. 19grs. of dollied and specimens, and 1,562ozs. 18dwts. 22grs. of alluvial.
1898	107,622 7 3	*d* 99,672 16 18	127,227 1 8	
1899	154,679 2 3	*e* 126,144 6 9	113,558 16 20	
Total	**349,905 2 3**	**364,790 8 0**	**644,663 4 10**	

Broad Arrow Goldfield.

The Broad Arrow Field embraces an area of 590 square miles, and is defined by the authorities as being:—

Bounded by lines starting from Survey Station R3; thence East about 17 miles 30 chains to a point North of the most Northerly corner of the East Coolgardie Goldfield; thence South about 29 miles 70 chains to that corner; thence about 234° 51′ 14½ miles to the 40-mile post on part of the Eastern boundary of the Coolgardie Goldfield; thence about 324° 46′ 9 miles 32 chains 44 links; thence North 30 miles 47 chains 56 links to the starting point.

The most Northerly mining centre of the field is Bardoc, and an area of about 40 square miles has been geologically mapped by

Mr. Blatchford, the Assistant Geologist. According to this officer's researches, it seems that the geological features and mode of occurrence of the ore deposits bear a strong similarity to the Coolgardie Goldfield. By far the larger portion of the field is covered with a varying thickness of loose, incoherent material, and the ubiquitous nodular ironstone beds.

These latter usually cover the higher ground in isolated patches, which at one time were virtually continuous. Where any good section is visible, it is invariably found that the ironstone gradually merges into the underlying rocks, and the iron oxides of the basic rock-forming minerals gradually replace the less basic constituents. These ferruginous beds have not yet proved auriferous.

The hornblendic rocks form by far the largest area of any of the rocks exposed at the surface.

A few isolated outcrops of a coarse-grained micaceous granite make their appearance from beneath the superficial deposits.

An important feature of the field are those narrow dykes (?) of some acidic rock—the percentage of silica in which, as determined in the laboratory, fluctuates between 51 to 68 per cent. There are, however, good grounds for believing that some, at any rate, of these dykes (?) are, in reality, contemporaneous lava flows, and that some of the enclosing rocks, almost universally mapped as basic rocks, are merely transmuted sedimentary rocks.

The gold produced from this centre has been derived from three sources, viz.:—Alluvial deposits, lode formations, and quartz reefs. The gold from the alluvial deposits presents all the usual characters. The lodes, so far as observations have been carried, are usually banded, and practically distinguishable from the country rock only by their auriferous character. The quartz reefs, which invariably occur in intimate association with the acid eruptive dykes, are of two distinct varieties. The first occur as lenticular patches, from which small quartz veins emanate in all directions. These branching veins appear to be the richer.

The second type are those banded rocks which consist of alternating layers of crypto-crystalline quartz and hematite. The proportion of oxides of iron varies from a practically pure hematite to a quartz rock, through which such small quantities of hematite are disseminated as to give it a brown or bluish appearance. These banded rocks seem to have been permeated with secondary silica, which has also penetrated the surrounding rocks. Although these banded quartzites have proved auriferous, none of them have so far shown themselves to be payable; in the circumstance that these banded quartz rocks are a possible source of gold, they are identical with the quartzites of Peak Hill (to which reference has been made on an earlier page), and of Mount Margaret.

The deposits of Bardoc have yielded 8,424ozs. of gold by the crushing of 11,710 tons of ore; being at the rate of 14dwts. per ton.

This gold has been derived almost exclusively from quartz reefs of the first type.

Our knowledge of the ore deposits in the more immediate vicinity of Broad Arrow is somewhat meagre. According to Mr. H. P. Woodward* there are two principal lines of lode in the neighbourhood of Broad Arrow; the two which have a more or less North-Westerly trend are about a third of a mile apart. These, in all probability, are the Southerly continuation of some of those lodes which have been mapped in the Bardoc neighbourhood.

A good deal of prospecting seems to have been carried out in the search for deep leads in the vicinity of Bardoc. Despite the fact that some of the claims got good prospects, it is asserted that the true course of the lead had not been determined. Only 114ozs. of alluvial gold have been officially reported from the Broad Arrow Field for the year 1899.

The following table gives the yield of the Broad Arrow Goldfield:—

Yield of the Broad Arrow Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons cwts. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	*a.* Complete details not available.
1896	*a* 1,536 4 0	*b* 9,129 5 0	*a*	*b.* Complete details not available, but includes 250 ozs. from unknown tons.
1897	19,636 6 0	*c* 14,464 10 18	*d* 4,159 5 9	*c.* Includes 27ozs. 4dwts. of dollied and specimens.
1898	32,004 1 1	*e* 27,726 8 14	24,631 8 20	*d.* No details available prior to 1st September, 1897.
1899	60,032 8 0	*f* 48,309 2 1	36,020 15 19	*e.* Includes 1,754oz. 5grs. of dollied and specimens.
Total	**113,208 19 1**	**99,629 6 9**	**64,811 10 0**	*f.* Includes 240ozs. 3dwts. 15grs. of dollied and specimens, and 114ozs. 4dwts. 3grs. of alluvial.

East Coolgardie Goldfield.

This comparatively small field, the most productive in Australia, embraces an area of 632 square miles; it is defined by the authorities as being:—

Bounded by lines starting from a mile post on the Eastern boundary of the Coolgardie Goldfield, 40 miles Southerly from Survey Station R3, and extending 144° 46′ 26 miles 62 chains 37 links along a surveyed line to the North-East corner of Location 53; thence Southerly along the Eastern boundary of Location 53 and the Western boundary of Location 51 to the South-West corner of Location 51; thence along the boundaries of that Location Easterly 119 chains 87 links, Northerly 60 chains, Easterly 160 chains to a point on the Western boundaries of Location 48, Southerly 564 chains 87 links, Easterly 443 chains 91 links to the South-East corner of that Location; thence Easterly about 7 miles 65 chains to a point South of the

* Mining Handbook. Perth: By Authority, 1895; p. 110.

South-East corner of Location 45; thence North to the said corner; thence North along the Eastern boundary of Location 45 4 miles to its North-East corner; thence about 342° 10′ about 1 mile 64 chains to the South-East corner of Location 44; thence along the Eastern boundary of Location 44 to its North-East corner; thence about 321° 35′ about 30 miles 53 chains to a point bearing about 54° 50′ from the 40-mile post on the Eastern boundary of the Coolgardie Goldfield; thence about 234° 50′ about 14½ miles to the starting point.

Kalgoorlie, the officia centre of the East Coolgardie Goldfield, the most productive field in Australasia or the British Colonies, was originally named Hannan's, after the original discoverer, Patrick Hannan.

The principal topographical feature of the field consists of a low broken range, of which Mount Charlotte, 1,378 feet above sea-level, forms the highest summit, and which trends generally North-North-West from the head of Hannan's Lake. This line of comparatively low hills diminishes in altitude from Mount Charlotte to a mere ridge, which gradually merges into the flat ground surrounding the lake, and forms the main water-parting of the district. To the Eastward, the country extends in a wide gently sloping valley, with a Southerly fall, flanked by a line of low hills, some six or seven miles distant; to the Westward is another valley of about two miles in width.

By far the larger portion of the field is covered with a mantle of reddish loamy soil, and other superficial accumulations of variable thickness. These superficial deposits consist of ironstone gravels and cement, passing in certain isolated localities into practically pure brown hematite. Some of these surface deposits have proved to be highly auriferous in places.

The rocks of the field consist of talc, mica, hornblende, and chlorite schists, intersected by dykes and masses of certain igneous rocks, the exact nature of which has not yet been determined. At the surface these rocks have been decomposed into a more or less mottled clay. Mining operations have shown that this zone of alteration extends to very variable depths, fluctuating between 50 and 400 feet, which latter, however, is exceptional. The following is an analysis, made in the Survey Laboratory of one of the oxidised schists, from the 50ft. level in the Great Boulder Perseverance G.M. :—

	Water, H_2O hygroscopic	0·730
	„ „ combined	5·951
Soluble in hydrochloric acid	Ferrous oxide, FeO	1·600
	Ferric oxide, Fe_2O_3	36·285
	Alumina, Al_2O_3	3·120
	Manganese dioxide, MnO_2	0·969
	Sulphate of lime, $CaSO_4$	Trace
Insoluble	Silica, SiO_2	39·760
	Alumina, Al_2O_3	11·485
	Ferrous oxide, FeO	Trace
	Magnesia, MgO	Trace
		99·900

Gold ... ... 5ozs. 2dwts. 8grs. per ton
Silver ... ... 1oz. 14dwts. 16grs. per ton

Below the level beyond which decomposition does not extend, the strata pass gradually downwards into a very fine grained rock, the exact nature and origin of which is at present somewhat obscure. The composition of a characteristic sample of one of the undecomposed schists, carrying tellurides of gold, from the 300ft. level of the Lake View Consols G.M., was found, on analysis in the official laboratory, to be as follows :—

	Water, H_2O Hygroscopic	0·402
	,, ,, Combined	1·809
Soluble in hydrochloric acid	Carbonate of lime, $CaCo_3$	10·882
	,, magnesia, $MgCo_3$	6·315
	,, iron, $FeCO_3$	1·553
	Ferrous oxide, FeO	1·360
	Ferric oxide, Fe_2O_3	1·541
	Alumina, Al_2O_3	1·326
	Manganese protoxide, MnO	Trace
	Phosphoric acid	Trace
Soluble in nitric acid	Iron, Fe	3·990
	Sulphur, S	4·417
	Tellurium, Te	Trace
Insoluble	Silica, SiO_2	51·271
	Titanic oxide, TiO_2	0·226
	Alumina, Al_2O_3	12·519
	Ferrous oxide, FeO	0·311
	Lime, CaO	0·313
	Magnesia, MgO	1·159
	Alkalies and loss	0·606
		100·000

Gold ... ... 9ozs. 12dwts. 18grs. per ton.
Silver ... ... 6ozs. 7dwts. 8grs. ,,

Some of the Kalgoorlie rocks have been microscopically examined at the hands of Mr. Card, the Petrographer to the Geological Survey of New South Wales, and, as a result of the chemical and microscopical investigations, this gentleman thus summarises his deductions :—

(1). The country rock is the same throughout the field ; broadly speaking, the description of one would apply to the other. They all agree in containing titaniferous iron ore, quartz, and mica. (2.) The ore bodies are simply more highly altered country rock. It will be noted that the titaniferous iron ore and primary quartz occur in the ore, as in the country, with a tendency, however, to granulation. (3.) The rock is of igneous origin, and in all probability of great geological antiquity. The pegmatitic structure and mineralogical constitution leave no doubt as to the origin, and the extreme alteration, of a deep-seated character, proves the antiquity. Titaniferous iron ore is thus found (. . Great Boulder Mine) completely converted into opaque yellowish-white products ; very much of the original silicates has been replaced by seicitic material, and the primary quartz has been split up into groups of fragments or completely absorbed. (4.) The country rock affords but very little indication of shattering or crushing; the alteration it has undergone has been chemical rather than cataclastic—effected under the influence of high

temperature and steady pressure. Subsequently to this deep-seated chemical alteration, mountain-making forces made themselves felt along certain directions, crushing the rocks to some extent, and (more particularly) inducing foliation in the sericite, and consequently a certain amount of jessility in the rock. This effect has seldom been sufficiently pronounced to produce a general foliation of the whole, and convert it into a true schist. The contact metamorphism that would result from the late intrusions if, as seems probable, there were more than one, must not be overlooked. (5.) The telluride of gold, together with the associated carbonates of lime and magnesia, and the secondary quartz, have been introduced into the ore body by solutions which found ready access along the planes of parting produced by the incipient foliation. That much of the chlorite has been introduced in the same way seems probable from its frequent occurrence in wavy bands; alumina is also present in the mine waters."*

The gold of Kalgoorlie is found both in lodes and in superficial accumulations, which owe their origin to the disintegration of the lodes, etc. These superficial accumulations have, so far as official records show, produced only 1,229ozs. of gold; the lodes however are by far the most important, for they have turned out 1,717,298ozs. of gold since the first discovery of the field.

The lodes of Kalgoorlie consist of a series of almost vertical banded schistose formations (merely country rock more or less altered by dynamic changes), which have a general trend of from North 30° West to North 50° West. These deposits are lenticular in habit, the lenses being often of great length. Instances occur which go to prove that some of these may reach over half-a-mile in length. At times, however, the lateral continuity of the lenses is interrupted by faults of very variable downthrow. As a general rule the ore deposits have no well-defined walls, but seem to pass insensibly into the surrounding rock. The lodes are often traversed by a network of quartz veins, which ramify in all directions.

There is abundant evidence attesting the fact that the rocks have been subjected to profound dynamic phenomena, which has resulted in the production of lines of weakness along which mineral bearing solutions have found a comparatively easy passage. The width of the ore bodies reaches as much as 80 feet in places.

The gold occurs free as tellurides and as auriferous pyrrhotite. The free gold presents such characters as point to its having been derived from the oxidation of the tellurium-bearing minerals; the decomposition of the auriferous pyrites may also be the source of some portion of it. The free gold often occurs in spongy or cellular masses of varying sizes and shapes, and is at times coated with a dull clayey ferruginous material of a yellow colour, known as "mustard gold," which may represent an oxidised form of tellurium. The tellurides of gold occur chiefly as Calaverite. The

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* Geo. W. Card. Notes on the Country Rock of the Kalgoorlie Goldfield. Rec. Geol. Surv., N.S.W. Vol. VI. part 1, 1898. Sydney: By Authority pp. 38-39.

following analyses of the telluride from this district have been made:—

Chemical Analyses of Tellurides from Kalgoorlie.

	I.	II.	III.	IV.	V.
Tellurium, Te	59·69	56·64	57·27	49·48	37·26
Gold, Au	38·70	41·76	41·37	Trace.	20·72
Silver, Ag	1·66	0·80	0·58	0·12	30·98
Mercury, Hg	...	...	...	50·40	10·86
Sulphur, S	0·09	...	...	...	0·13
Copper, Cu	0·21	...	...	...	0·05
Iron, Fe	0·18	...	...	...	...
Lead, Pl	Trace.	...	...	...	...
Bismuth, Bi	Trace.	...	...	...	...
Zinc, Zn	Trace.	...	...	...	...
Total	100·53	99·20	99·22	100·00	100·00
Sp. Gr. ...	...	...	...	9·21	8·71

I.—Calaverite: Lake View Consols Mine—Analyst, G. J. Rogers.
II.—Calaverite: Australia Mine—Analyst, J. C. H. Mingaye.
III.—Calaverite: Australia Mine—Analyst, E. S. Simpson.
IV.—Coloradoite: Australia Mine—E. S. Simpson.
V.—Kalgoorlite: Lake View and Boulder Junction Mine—Analyst, J. C. H. Mingaye.

The value of the different ore deposits of the East Coolgardie Field naturally vary considerably; from a few pennyweights up to as much as 61oz. to the ton of ore treated. The ore treated, according to the official statistics, yielded during the years previous to 1898, gold at the rate of 2oz. 13dwts. 11grs. per ton; during 1898, 1oz. 10dwts. 22grs. per ton; during 1899, 1oz. 16dwts. 15grs. per ton; while the average of all the ore crushed is about 1oz. 18dwts. 8grs. per ton.

The following table shows the yield of the East Coolgardie Field:—

Yield of the East Coolgardie Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons.	cwt.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	*a.* Complete details not available.
1896	*a* 43,270	18	0	*b* 143,072	13	12	*c* 85,287	1	7	*b.* Complete details not available, but includes 500ozs. from unknown tons.
1897	121,321	3	1	*d* 297,520	2	18	300,037	4	18	*c.* Included with Coolgardie prior to 1st May, 1896.
1898	264,324	15	1	*e* 422,391	17	3	450,312	5	10	*d.* Includes 46oz. 3dwt. of dollied and specimens. *e.* Includes 148ozs. of dollied and specimens.
1899	466,759	1	3	*f* 855,404	17	7	890,566	7	11	*f.* Includes 29ozs. 11 dwts. 3grs. of dollied and specimens, and 590ozs. 5dwts. 2grs. of alluvial.
Total	**895,675**	**18**	**1**	**1,718,389**	**10**	**16**	**1,726,202**	**18**	**22**	

North-East Coolgardie Goldfield.

This goldfield embraces an area of 21,542 square miles, and according to the authorities it is comprised by :—

Lines starting from a point situate about 17 miles 30 chains east of Survey Station R 3; thence South about 29 miles 70 chains to the most Northerly corner of the East Coolgardie Goldfield; thence about 141° 35′ about 30 miles 53 chains to the North-East corner of Location 44; thence along the Eastern boundary of that location to its South-East corner; thence about 162° 10′ about 1 mile 64 chains to the North-East corner of Location 45; thence along the Eastern boundary of that location to its South-East corner; thence South to a point 7 miles 65 chains East from the South-East corner of Location 48; thence East about 27 miles 15 chains; thence South about 48 miles to the South-East corner of the Coolgardie Goldfield; thence East to the 125th meridan of East longitude; thence North along that meridan to a point East of Survey Station R 3 aforesaid; thence West to starting point.

For administrative purposes the field is divided into three districts:—Kanowna (White Feather), Bulong (I.O.U.), and Kurnalpi.

Kanowna.—The fundamental rocks of the Kanowna district are chlorite, talcose, and serpentinous schists, invaded by dykes of acid eruptive rocks, which have a prevailing North-Easterly strike and an Easterly dip. The schists, so far as has been disclosed by mining operations, are all in an advanced stage of decomposition. They have proved to be highly auriferous in places. The granitic rocks which contain gold in appreciable quantity are reticulated by interlacing quartz veins, which are also auriferous; these appear to have been prospected with considerable success.

According to H. P. Woodward* a large quartz reef from 3 feet to 6 feet in width, and running for miles in a more or less North and South direction, forms a prominent feature in the district. Several other parallel quartz reefs and cross reefs occur, and they are all situated to the East of the main reef. The gold shoots in the main reef contain the metal in a coarse form, and carry, besides, a considerable quantity of fine gold not visible in the stone. In the lower levels the gold is associated with pyrites (especially chalcopyrite) and mispickel.

The principal interest, however, at Kanowna at present attaches to the alluvial leads, which have been extensively worked. The most prominent of these is the North Lead, which lies in a natural depression which has been traced from the Cemetery to G.M.L. 918. The North Lead lies in an old watercourse carved out of the older rocks, and has been proved to be not merely a simple isolated run of auriferous gravel, but part of a series of old stream deposits, which took their rise in the comparatively elevated ground to the East and flowed in a general Westerly direction.

The Lead trends generally Northwards as far as the G.M.L. 923, when its course is suddenly deflected to the East. It is joined near the Birthday Gift Claim by what is known as Wilson's

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* *Loc. Cit.*

Gully Lead, which enters from the South. Some distance below the junction the North Lead loses itself in an extensive flat, which may prove to be merely a lake-like expansion of its channel. The connection of the Q.E.D. Lead on the North, although it trends in such a direction as to fall into the North Lead, has not yet been definitely proved. All things point to such a connection, though it may be that the lead has been lost by denudation.

The width of the old stream varies from 2 to 80 feet, having an average, according to Departmental observations, of about 15 feet. The thickness of the deposit in the old channel varies from a few inches up to as much as 90 feet. The fall of the lead is about at the rate of 40 feet to the mile.

The deposits filling the old watercourse naturally vary somewhat in different portions. They consist first of a variable thickness of surface loam, etc., succeeded by ironstone gravels partially cemented in places by kaolin and oxide of iron into solid rock. Beneath this lies a bed or beds of practically pure kaolin ("pug"), and a varying thickness of a pebbly quartz wash. The wash contains rounded and subangular pebbles of quartz, which, in the upper portion of the deposit, is often associated with kaolin and sand. This quartz wash is cemented by secondary silica into a hard, compact rock, which, in hand specimens, might easily be mistaken for quartzite.

So far as mining operations have, up to the present, been carried, it would seem that the whole of the detrital deposits have not proved auriferous. Most of the alluvial gold has been won from the pebbly quartz wash, although the overlying kaolin ("pug") and ironstone gravels have also yielded a certain quantity.

The ultimate derivation of the gold in the North Lead is from the quartz veins and lodes (upon which the wash directly reposes in places) by which the crystalline rocks are traversed; for the gold is not exclusively in the form of grains, scales, etc., but is found occurring in the quartz pebbles themselves.

In addition to what may be called detrital gold there is another massive, arborescent, or coarsely crystalline form which occurs, filling certain irregular cracks, and covering cleavage planes or shrinkage cracks, so as to present the appearance of painted surfaces.

The mode of occurrence, associations, and character of this gold all point to a secondary origin; and it is of importance to note that this, what may be called secondary gold, has been deposited from solution, not only in the alluvium and other superficial deposits, but also in the zone of decomposition of the bed-rock. These secondary forms, which result in the superficial enrichment of many auriferous deposits, are a common feature in the mineral fields of the Colony.

Of the age of the North Lead there is no evidence available at the present time. Owing to the fact that at a date subsequent to

its formation a sufficient length of time has elapsed to allow of the lead being sealed up by great accumulations of superficial deposits (some of which have been consolidated into solid rock), may point to considerable geological antiquity.

It is impossible to arrive at the gold yield of the portion of Kanowna traversed by the old watercourse, owing to there being no separate returns furnished by the claim holders on the North Lead. The returns, which are appended, show that up to the end of 1899, the lodes from Kanowna have yielded 68,815ozs. of gold by crushing 72,939 tons of ore. The alluvial deposits, the gravels, have yielded 90,652ozs. of gold, and 97,081 tons of cement crushed have been responsible for 139,023ozs. From these data it will be seen that the alluvial deposits turned out 77 per cent. of the total production.

Tables showing the Gold production of Kanowna.

I.—Lodes.

Year.	Ore crushed.	Total Yield.	Rate per ton.
	tons cwts. qrs.	ozs. dwts. grs.	ozs. dwts. grs.
Previous to 1898 ...	27,365 11 0	28,243 15 11	1 0 15
1898	24,838 2 0	20,892 0 0	0 16 19
1899	20,735 10 0	19,680 0 14	0 18 23
Total	**72,939 3 0**	**68,815 16 1**	**0 18 20**

II.—Alluvial Deposits.

(*a.*) *Gravels.*

Year.	Ore crushed.	Total Yield.	Rate per ton.
Previous to 1898 ...	... ...	10,611 18 10	
1898	... ...	63,548 0 10	
1899	... ...	17,492 15 2	
Total	... ...	**91,652 13 22**	

(*b.*) *Cement.*

Year.	Ore crushed.	Total Yield.	Rate per ton.
Previous to 1898	*	*	
1898	45,983 4 2	68,183 10 22	1 9 15
1899	51,098 14 2	71,839 18 11	1 8 2
Total	**97,081 19 0**	**140,023 5 9**	**1 8 20**

* No data.

There are no data available by which the average fineness of the gold from the North Lead can be obtained.

That many other similar leads probably exist is obvious from the geological structure of the district, though, owing to the completeness by which they have been sealed up by the more recent accumulations, they can only be tapped by a judicious system of prospecting.

It is desirable that the other leads in the district be accurately mapped, contour surveys made, and every accessible shaft carefully examined, after which it should be possible to throw considerable light upon the probable trend of the old stream courses; for so long as these continue there is always a chance of payable deposits occurring, though they are hardly likely to be discovered without many failures.

The mining centre of Mulgarrie lies about 20 miles North-East of Kanowna. The strata consist chiefly of hornblendic rocks, intersected by acidic dykes, the whole being overlaid in places by recent superficial accumulations, which latter attain a thickness of over 100 feet in places.

The hornblendic rocks are usually in a more or less highly decomposed state, which tends to conceal their true character. The acidic dykes form long narrow bands trending usually North-West and South-East, and with a high dip to the East. These dykes appear to be younger than the schistose rocks. An isolated patch of a hornblende granite outcrops in one portion of the district, but its relation to the surrounding rocks is far from clear. A prominent feature of the field are those banded siliceous rocks which bear a marked resemblance to the quartzites of the Murchison. The rocks (in reality hematitic quartzites) are composed of alternations of quartzite and brown hematite and a fine grained banded practically pure quartz rock. This rock is often reticulated with quartz veins.

The quartz reefs of the district, which are intimately associated with the banded quartzites, have a prevailing strike of North-West, with an underlie to either the East or West.

Hayes' New Find is situated near the Northern boundary of the Kanowna district, distant 24 miles North-East of Kanowna, and about 30 miles due East from Bardoc.

A very large portion of the surface of the field is covered with red loam. The staple formation of the field consists of serpentinous schists, which have a prevailing strike of from North 15 to 20 degrees West. As these schists are followed underground their schistosity is less apparent, and disappears entirely at about 200 feet.

A large portion of the field is made up of a quartz porphyry which seems to invade the schists. The rock has undergone extensive decomposition at the surface, and, in places, would be best described as kaolin. Some of the weathered portions of the porphyry exhibit a schistose structure, which is coincident with that by which the serpentinous beds are traversed. The porphyry is intersected by certain basic dykes, the exact nature of which it is impossible, owing to the extensive decomposition, to define.

The higher portions of the district are covered by the remains of a once continuous sedimentary deposit and ironstone gravels. Some of these sedimentary beds are really quartzites, others are of

a softer sandy nature; neither, however, have proved to be auriferous.

Bulong.—The Bulong or I.O.U. Mining District never has been the subject of geological examination, so that the information is far from complete. The country rock is described by S. Göczel, a former member of the staff, as being partly diorite and partly diabase, both having been much subject to decomposition. A large North and South reef is said to form an important feature; two miles to the West of this is a stretch of country, about two miles long, in which several gold-bearing lodes occur.

On the ground held by the Mystery Gold Mining Company large quantities of gold have been obtained from the superficial covering of a ferruginous deposit (laterite) which covers such extensive areas in the Colony. The deposit is described as a gritty limonite, interbedded with clayey ironstone.

The alluvial deposits of Bulong, some of which have been worked at a depth of over 100 feet, have yielded, up to the close of 1899, 15,390ozs. of gold. Several leads have been worked, but as they have never been geologically mapped, details in connection with them are wanting.

Kurnalpi.—Of the Kurnalpi District practically no information is available. The alluvial deposits, however, have yielded up to the close of 1899, 5,782ozs. of gold.

The following table gives the production of the North-East Coolgardie Goldfield:—

Yield of the North-East Coolgardie Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons.	cwts.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1896	*a* 5,682	6	0	*b* 8,975	19	0	*c* 4,113	3	15	*a*. Complete details not available. *b*. Complete details not available, but includes 150ozs. of dollied and specimens. *c*. Prior to 1st May, 1898, included with Coolgardie.
1897	28,546	5	0	*d* 40,453	1	21	32,905	16	8	*d*. Includes 866oz. 4dwts. 12grs. dollied and specimens, and 10,917oz. 18 dwts. 22grs. of alluvial.
1898	80,095	16	2	*e* 170,441	14	18	125,240	9	19	*e*. Includes 1,115oz. 11 dwts. 12grs. of dollied and specimens, and 69,069oz. 15dwts. 6grs. of alluvial.
1899	82,736	6	0	*f* 112,845	13	21	64,470	5	14	*f*. Includes 1,648oz. 17 dwts. 11grs. of dollied and specimens and 34,527oz. 15dwts. 22grs. of alluvial.
Total	**197,060**	**13**	**2**	**332,716**	**9**	**12**	**226,729**	**15**	**8**	

Dundas Goldfield.

This field, the most Southerly of the Eastern fields, embraces an area of 17,848 square miles, which, according to the authorities, is:—

Bounded on the North by an East and West line passing through the summit of a granite rock near the 50-Mile Soak, on the Dundas and Lake Lefroy Road; on the East by a North and South line through a point 52 miles East of Mount Ridley; on the South by an East and West line passing through the summit of Mount Ridley; on the West by the production South of the Western boundary of the Coolgardie Goldfield.

It seems that Mr. Moir, of Fanny's Cove, was the first to detect gold in the country now embraced by this field. The discovery was made in the alluvium of one of the creeks when this gentleman was engaged in searching for pastoral lands; no effort would appear to have been made to give further attention to the district until some years later, when Mr. Moir organised a prospecting party, which, however, was not successful. About the same time further prospecting was carried out by other parties which resulted in the discovery of a rich reef called the "May Bell" and another called the "Scotia."

The staple geological feature of the Dundas field consists of the foliated granites or gneisses associated with certain schistose rocks, hornblende, mica, and chlorite schists, amphibolites, hematite-bearing quartzites, felsitic dykes, and other igneous rocks.

A series of quartz reefs, parallel to these dykes, trend in a general North-North-Easterly direction; some of these are in intimate association with certain of the hematite-bearing quartzites of the type alluded to on a previous page.

The surface of a large portion of the district is covered with ironstone gravel and conglomerate which effectually conceals the underlying rocks, and renders prospecting exceptionally difficult.

The gold in the reefs is sometimes associated with native bismuth, and was recorded by Mr. S. Göczel in 1893.

It does not appear that Dundas will attain any prominence as an alluvial field, although as a reefing district its structural features are highly favourable.

The following table gives the yield of the Dundas field:—

Yield of the Dundas Goldfield.

Year.	Ore crushed.			Yield of Gold therefrom.			Gold exported.			Remarks.
	tons	cwt.	qrs.	ozs.	dwts.	grs.	ozs.	dwts.	grs.	
1893							147	19	11	*a.* Details not available.
1894	*a* 3,020	0	0	*a* 3,983	10	0	228	7	12	*b.* Includes 77ozs. 10dwts. of dollied and specimens.
1895							241	18	2	*c.* Includes 5ozs. 12dwts. of dollied and specimens.
1896							4,350	6	6	*d.* Includes 146ozs. 3dwts. 14grs. of dollied and specimens, and 142ozs. 15dwts. 1gr. of alluvial.
1897	16,882	19	2	*b* 19,279	18	10	19,310	16	7	
1898	30,928	7	0	*c* 36,798	9	14	32,031	16	6	
1899	59,470	16	0	*d* 44,356	15	18	44,691	6	11	
Total	**110,302**	**2**	**2**	**104,418**	**13**	**18**	**101,002**	**10**	**7**	

Donnybrook Goldfield.

This little Goldfield is situated between Geographe Bay and the Greenbushes Tinfield. The authorities define its boundaries as follows :—

Starting from the South-Western corner of Reserve 6321 (Covenley Townsite); thence North about 60 chains to the Boyanup–Bridgetown Railway Reserve; thence by the Western boundary of said Railway Reserve in a general North-Westerly direction about 14¼ miles to its intersection with the Eastern boundary of Wellington Location 239; thence North about 10 chains to the left bank of the Preston River; thence by said River in a general North-Easterly direction about 2¼ miles to the North-Eastern corner of Reserve 645A; thence North about 3 miles; thence West about 7 miles to the Eastern boundary of Boyanup–Bridgetown Railway Reserve; thence by said Railway Reserve in a general South-Easterly direction about 3¾ miles to a point North of North-West corner of Wellington Location 836; thence South about 13¼ miles; thence East about 9¼ miles to the point of commencement.

The field has been reported upon by the Assistant Geologist, from whose reports the following details have been extracted.

Donnybrook is situated on the Bunbury and Bridgetown Railway, and is 26 miles South-East of Bunbury and 143 miles by rail from Fremantle. The scene of mining operations is some two miles to the South of the Donnybrook townsite, on a small branch of the Preston River, in the Blackwood Range. Gold would seem to have been first discovered in 1897, by a party of prospectors searching for alluvial gold. Further investigations carried on eventually led to the discovery of auriferous quartz veins, from which most of the gold had originally been shed.

The country, which is extremely hilly and thickly timbered, is for the most part covered with ironstone gravel deposits, which effectually conceals the underlying rocks, except in the gullies and sides of the hills.

The country rocks of the field consist of massive hornblende and gnessic granites intersected by a belt of hornblende rock trending North and South, and traceable for some considerable distance in a Southerly direction. The width of the belt of dioritic rock varies from a quarter of a mile, though it has never been found to exceed a mile. In hand specimens the rock is found to consist of coarse hornblende crystals associated with more or less decomposed felspars. The Western edge of the dyke has a banded structure, and resembles hornblende schist; in isolated cases it is found occurring as an exceedingly fine grained and exceptionally hard rock. The granite naturally varies considerably in texture and composition, though, as a whole, it is a hornblende granite. In several localities the hornblende is almost entirely replaced by muscovite mica. Epidote is found occurring as a rock-forming mineral in the granite. Recent developments have shown the existence of extensive deposits of sandstone lying beneath the ubiquitous ironstone gravels. These sandstones, which are usually of a light grey colour, are fine grained and of an even

texture. The maximum thickness attained by the sandstones is not less than 150 feet.

The quartz reefs all occur in the granite to the West of the diorite, always in close proximity to the junction of the two rocks. The general strike of the reefs is a little to the West of North and East of South, with a high dip to the East. Mining operations have shown that payable quartz reefs occur in the sandstone as well as in the unaltered granite.

Some of the gold from Donnybrook occurs in the filmy arborescent form, which points to a secondary origin.

From the appended table of the returns showing the yield of Donnybrook it appears that the total output is 579ozs. of gold, of which 32ozs. is alluvial.

Yield of the Donnybrook Goldfield.

Year.	Ore crushed.	Yield of Gold therefrom.	Gold exported.	Remarks.
	tons. cwts. qrs.	ozs. dwts. grs.	ozs. dwts. grs.	
1898	18 0 0	14 13 0	*a*	*a*. No details available prior to 1st March, 1899.
1899	294 16 0	*b* 511 9 18	*a* 309 18 16	*b*. Includes 32ozs. 2dwts. of alluvial.
Total	**312 16 0**	**526 2 18**	**309 18 16**	

CHAPTER IV.

Other Localities at which Gold has been discovered.

Bowes River, Peterwangey Hill, Wongan Hills, Black Boy Hill.

Bowes River.—The banks of the more important watercourses in the Champion Bay District are skirted by a width, more or less great, of recent superficial deposits. It is worthy of note that Mr. F. T. Gregory, writing in 1861, said that "specks of gold have also been obtained by washing the sands in the Bowes River." *

Peterwangey Hill.—A little gold was found in the year 1868 in the alluvium on the North side of Peterwangey Hill, which is situated on the Irwin River, about 63 miles to the Eastward of Geraldton. The gold is in the spurs, which are capped with large deposits of red clay, sand, pipe-clay, and nodular ferruginous claystones. Judging from its highly-waterworn appearance, and the fact that the mineral veins of this locality are not auriferous, it has probably been derived from some old stream bed which passed across this country in a different direction and at a higher level than the existing rivers. Nothing certain can, however, be stated on this point until the district has been examined in detail and all the old watercourses mapped. The rocks here are mostly granite, with diorite dykes, and occasionally quartz reefs of highly crystalline character; but a few miles lower down the river, and also further to the Eastward, the country assumes a more promising aspect for gold, the rocks being more schistose, and containing many nice-looking quartz and ironstone lodes, though none have yet proved to be auriferous. †

Wongan Hills.—The Wongan Hills would seem to have been first reported upon by Mr. H. Y. L. Brown, in the year 1871, who noted that they were "composed of a hard blue metamorphic schist, sometimes micaceous, at others hornblendic, dipping vertically, and striking North and South. It is a representative southwards of the Tallering, Nancarrong, and Blue Mountain series of rocks, and is overlaid by a thick capping of ferruginous sandstone and claystone." ‡

The year 1888 would appear to have seen the first recorded occurrence of gold in the Wongan Hills. The district was visited by Mr. H. P. Woodward, then Government Geologist, from whose pen the following description emanated:—

They (the Wongan Hills) appear from the westward to be two or three isolated peaks, but on approach these are found to be the highest points,

* On the Geology of Part of Western Australia. Q.T.G.S., London, 1861.

† H. P. Woodward. Mining Handbook. Perth: By Authority, 1895; pp. 115.

‡ On the Geology of the Country passed over from the 21st August to the 17th Septem- 1871. Perth: By Authority, 1872.

and to form the abrupt termination of a range which runs in a North-East direction. They are flat-topped hills, presenting a bold escarpment to the South-West of about 300 feet above the surrounding clay flats; this face is probably caused by a line of fault, which would also account for the springs near their base. The rocks are metamorphic and crystalline, with veins of radiated actinolite and small quartz veins. They strike North-East and South-West, following the direction of the range, dipping at an angle of 60° to the North-West and making their appearance again in a small hill to the North called the Little Wongan. Granite rocks form the low ridges to the North and South; they are often almost covered by sand or ferruginous conglomerate. The highest peaks of the range are capped by a ferruginous conglomerate, nodular clay ironstone, intermixed with sand or clay, clays and ferruginous sandstones horizontally bedded. These beds also cap the low granite ridge, but occupy many different elevations, owing to the upheaval of the Wongan to the North-East of the fault. The recent deposits are sand, clay, and loam. Of these the sand greatly predominates, forming large plains to the West and North, occasionally interrupted by large salt flats and claypans. The loam forms patches of rich red soil (generally thickly timbered with gimlet wood). There is very little to be seen of the plutonic rocks at the surface. A few small diorite dykes occur in the range, and probably some of the granites at the base of the hills are intrusive. Quartz reefs in this district are quite a rarity. They are small, of a yellow glassy appearance, containing either pyrites or brown hematite and a little gold. They have well-defined walls, dipping at an angle of about 65° in a North-West direction, following the strike of the rocks North-East and South-West. When opened, some very good specimens and prospects, both from the reefs and the casing, were obtained. The size of the reefs is unknown, as, owing to the hard nature of the ground, and to the discovery of many richer reefs at Yilgarn, they were abandoned. *

The country rock of the field consists of hornblende and micaceous schists, which are either vertical or are inclined to the West, and have a general northerly strike. Intersecting these beds are basic dykes, which would seem to be arranged in two series approximately at right angles to each other. The time at my disposal, however, did not admit of mapping the whole of these basic dykes. One basic dyke trends generally North and South; and another, the more conspicuous of the two, has a prevailing strike of North-East and South-West. No section was visible in which the dip of these igneous dykes could be made out; the impression left on the mind, however, is that they are vertical, or nearly so. In addition to these, however, are a series of acidic dykes striking in approximately the same direction as the prevailing trend of the enclosing schists. The most conspicuous of these occur in the country to the North of Bidjaronning Spring. They are of two types—viz., a very coarse variety of pegmatite and a somewhat fine-grained micaceous felsite. One of the most noticeable geological features of the area is the ferruginous conglomerate (?), which covers such an extensive tract of country in the neighbourhood. The conglomerate does not form a horizontal tableland, but, on the West, presents a steep bluff from six to eight feet in height, extending for considerable distances North and South, with scarcely any interruption. From the top of the escarpment the deposit dips gradually to the East, and seems to pass beneath the sandy soil which forms the flat country on the other side of the range. The

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* H. P. Woodward. Mining Handbook to the Colony of Western Australia. 2nd Edition. Perth: By Authority, 1895; pp. 115-116.

conglomerate seems to have adapted itself to the original form of the ground upon which it was formed. Outliers of this conglomerate occur at several places on the Western fall, at elevations considerably below the general level of the range, and with a dip to the West at angles a little less than the average slope of the ground. It is quite evident that this deposit originally covered the whole of the Wongan Hills, and that extensive denudation has taken place since the conglomerate formed part of one continuous formation. In two or three localities watercourses have cut deep channels through the conglomerate, the most conspicuous being that creek which rises at about the centre of the country examined and flows gradually to the East through a narrow cañon-like channel.

Prospecting operations are at present confined to a relatively small area of the Wongan Hills; the workings are situated on the Western slope of the range, at some slight elevation above the general level of the surrounding country. So far as operations have at present been carried, the ore deposits which have been prospected consist of ordinary quartz reefs, through which various metalliferous ores are disseminated.

The reefs have a strike coincident with that of the enclosing rocks—viz., generally North and South. In several places the slopes of the hills are strewn with quartz fragments of such a character as to leave no doubt but that they had not travelled far from the position in which they had been deposited. Owing to the reefs and veins being lenticular in shape, it necessarily follows that it would only be in very exceptional cases that their outcrop would make any show on the surface. As a general rule the quartz is of a somewhat white-sugary appearance, with the exception of some of those veins at Little Wongan, which are of a limpid glassy appearance. The white-sugary variety of quartz carries hematite, limonite, azurite, malachite, and oxide of copper, together with actinolite, serpentine, and garnets. The oxides of iron are disseminated through the quartz in the form of irregular grains, as well as irregular veins traversing the quartz.

Up to the present time prospecting operations have been carried on only to a few feet from the surface, hence many details as to the structure of the reefs and other cognate points are not available.

The want of water during the greater portion of the year is a serious drawback. This, however, could no doubt be remedied by the sinking of wells in localities on the low ground at the base of the hills. It cannot, however, be said that up to the present any very promising results have been obtained by the prospecting in the district; the hope, however, may be reasonably indulged in that somewhere within the known linear extension of the Wongan Hill beds valuable discoveries may be made in the future.

Blackboy Hill.—At Cantincuti (popularly known as Black Boy Hill) situated at the head of Toodyay Brook, about 25 miles North

of the town of Newcastle, auriferous deposits have been found on private land.

The ground lies to the East of Blackboy Hill (Cantincuti), which consists of a mass of granitic gneiss. To this gneiss, on the East, succeeds a belt of about a mile in width, consisting of micaceous and quartz schist; the latter sometimes in flaggy beds. These metamorphic rocks trend generally North and South, and dip to the East at varying angles. They are intersected by diorite trending North-West and South-South-East. These beds are often concealed in part by a covering of sand and ferruginous rubble, the latter containing, in one or two localities, free gold. There are no quartz reefs, in the ordinary sense, exposed in any of the workings, but merely irregular lenticular veins of glassy quartz lying parallel to the planes of schistosity. The quartz contains, in places finely-disseminated pyrites, limonite, and, in some cases, free gold. The quartz schists are, in most cases, iron-bearing, and have been mistaken for quartz reefs of large size. The gold present is practically confined to the glassy quartz, and is present in small quantities throughout the belt of micaceous and quartz schists, and such being the case it is of course within the bounds of possibility that gold may prove to be sufficiently concentrated in any quartz reefs which may occur to be payable, but none have been discovered.

Bindoon.—A pyritous quartz reef has been worked at Bindoon, about 45 miles North-East of Perth. The rocks are stated to be slate and schist, with quartz reefs and diorite dykes, both of which have been proved to contain pyrites in fairly large quantities.

Dandalup.—Writing in 1871, with reference to Dandalup, Mr. H. Y. L. Brown remarked that the country rock consisted of a coarse porphyritic granite, intersected by dykes of different varieties of greenstone:—

> Several holes have been sunk along the creek here in searching for gold, through granite and greenstone detritus, quartz drift, etc. There are, however, no special indications which would lead anyone to expect gold here rather than in any other parts of the Darling Range.*

In 1896, prospecting was vigorously carried out in the neighbourhood, and an area was proclaimed a goldfield. Nothing, however, of a payable nature was discovered, though the district proved undoubtedly auriferous.

Brunswick River.—Prospecting operations have been carried out on private lands, situated about three miles above the Railway Station at Brunswick. The country rock consists of micaceous quartz schist or quartzite, carrying a fair proportion of pyrites. No true quartz reef had been opened up, but operations had been carried out upon beds of country rock, through which auriferous pyrites is disseminated. One of these beds of pyrites had a width of 18 feet. Appreciable quantities of gold were discovered in these

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* H. Y. Lyell Brown. Geological Report on country in the neighbourhood of Stanton Springs, Williams and Canning Rivers, Pinjarra, Bunbury, and Cape Leeuwin. Perth: By Authority, 1872.

beds; as, however, it seemed that the gold in a stone of this nature would be proportional to the amount of pyrites present, investigations were made in the official laboratory, and assays were made of the pyrites resulting from the crushing and the washing of the ore. The concentrates thus obtained assayed 19dwts. 14grs. of gold per ton; but, as the pyrites represented about four and a-half per cent. of picked stone, the actual assay value of the ore works out to be 21grs. per ton.

Greenbushes.—Gold has also been found in association with the tin ore at Greenbushes, but no details as to the mode of occurrence are available.

Kendinup.—Late in the sixties—

> Gold was found at Kendinup, on the Great Southern Railway, in a quartz reef, which contained much iron pyrites. . . . . The rocks in this neighbourhood are crystalline schists, containing many quarts reefs and diorite dykes, both carrying large quantities of iron pyrites, which contain small quantities of gold.*

Eastern Districts.—At York, and throughout the Eastern Districts, gold finds are reported from time to time, but these have never been proved to be of any value as yet; but there is not the slightest doubt that an auriferous belt extends South from the Wongan Hills by York along the Great Southern Railway to Kendinup.

The Darling Range—

> The Darling Range presents a bold escarpmen to the coastal plains, and is composed of very hard crystalline and granitic rocks, striking North and South, whilst at their base, on the Western side, here and there softer rocks, such as clay, slate, and sandstone, outcrop; and wherever they are met with they contain quartz and other mineral veins, with zinc, lead, and copper ores. All along this Western face, South of Perth, there are series of immense quartz reefs, carrying large quantities of pyrites, which, on assay, prove to carry gold, but in no case rich enough to pay.†

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* H. P. Woodward. *Loc. Cit.* † H. P. Woodward. *Loc. Cit.*

CHAPTER V.

LEAD AND COPPER.

NORTHAMPTON, WHIM WELL, ROEBOURNE, OTHER LOCALITIES.

NORTHAMPTON.

The inception of active mining operations in Western Australia dates from the year 1842, when lead and copper mines were first discovered in this district.

The first discovery of a copper lode was made at Wanerenooka by a man named Thomas Mason, who at that time was following the humble occupation of a shepherd in the employ of the late Mr. James Drummond.*

Mining in the early days was carried out in the most parsimonious manner, and sinking was discontinued when the lodes showed signs of contracting—a condition, however, to which all such deposits are subject. This circumstance, coupled with the low price of both lead and copper, would appear to have been the reason which led to the suspension of mining operations.

Mr. F. T. Gregory, writing in the year 1861, would seem to have been the first to describe the occurrence of the lodes of lead and copper, in the following words:—

These lodes take an almost invariable direction of North 32° East, with a general dip of about 80° to the West-North-West, and are accompanied by parallel dykes of whinstone, quartz, or porphyry, varying from a few feet to 50 or 60 yards in breadth.†

In the year 1871 Mr. H. Y. L. Brown, then Government Geologist, examined the neighbourhood, and, in his report,‡ gave a description of such of the properties as were at that time accessible. This report, and the accompanying small scale map, is long since out of print. Mr. Brown, who had exceptional opportunities of examining the mines, wrote in no uncertain terms as to the district affording a wide field for the profitable employment of capital. The report of Mr. Brown was followed in 1888 by that of Mr. H.

* H. P. Woodward. Mining Handbook to the Colony of Western Australia. Perth By Authority, 1895.

† On the Geology of a part of Western Australia. Q.J.G.S: London, 1861. Vol. XVII., p. 478.

‡ Geological and Mining Report on the Champion Bay Mining District, Western Australia. Perth: By Authority, 1871.

P. Woodward, from whose pen the best description§ of the mines emanated, and which has been laid under contribution:—

In this district the copper and lead ores occur associated together in the same lodes, with, sometimes, zincblende, ferruginous graphite, barytes, and quartz. The lodes, which have a course more or less North and South, make their appearance here and there, where the overlying mesozoic rocks have been removed, in a raised belt of country, about 110 miles long, stretching from the Geraldine mine, on the Murchison River, in the North, to the Irwin River, in the South. They consist of very large and rich deposits of lead and copper, which were successfully worked for many years. . . . The lead is found in the form of carbonate (Cerrusite) and sulphide (Galena) of great purity, and the lodes, which are of immense width, contain so little gangue mixed with the ore that the galena can be dressed, with very little labour, up to 83 or 84 per cent. . . . . . The copper ores are also very rich, consisting, near the surface, of the blue and green carbonates (Azurite and Malachite) with ferruginous oxides and a certain amount of native copper: whilst below the water level the lodes are almost entirely composed of sulphides (Copper Pyrites, Copper Glance, and Covellite). . . . . .

During a preliminary examination of the district in the early part of 1897, the association of the lodes with certain basic dykes, which traverse the country for considerable distances with a remarkably persistent trend, was forcibly apparent. These dykes being of commercial importance, owing to their intimate connection with the deposition of metalliferous minerals, it seemed that the greatest assistance the Geological Survey could render to private enterprise in such a district would be in the direction of accurately mapping these igneous rocks, and by so doing afford a reliable guide as to the horizontal extent of the ore bodies, and, possibly, lead to the discovery of others.

The district occupies an elevated tract of country drained by the tributaries of the Bowes River, which all take their rise in the rugged hills forming the most Northerly portion.

From beneath a series of sandstones and conglomerates emerge the crystalline rocks which form the matrices of the copper and lead lodes. These beds, which consist of granite, gneiss, mica schists, quartz schists, etc., are intersected by veins and masses of pegmatite. It was found almost impossible to draw any line separating each of these rocks, hence all have been delineated by the same distinctive marking on the attached plan. (Plate iii.)

The summit of a bare hill East of Brookside Farm, just above the junction of the Udandarra Creek with Nokenena Brook exposes a sheeted zone of micaceous and garnetiferous schist. The rock is traversed by a band of quartz, often much contorted and puckered, and stands out in such bold relief as to be readily followed by the eye across country. The general trend of these sheeted zones is North-West and South-East. Another similar parallel sheeted zone of garnetiferous gneiss occupies the country to the South-East of the Baddera Mine, at the head of the Udandarra Creek, and an identical band makes its appearance to the South-East of Reserve 1374, at the foot of the sandstone tableland at the head waters of the Bowes River. What appears to be a continuation of this band

§ H. P. Woodward, *Loc. Cit.*

is visible in the vicinity of Poison Well. It does not appear that these sheeted zones have been impregnated with metalliferous minerals. A remarkably persistent band of quartz schist can be traced from Two-Mile Hill to the South of the country examined. The schist, which presents a bold topographical feature, forms a horseshoe-shaped curve, passing through the Two-Mile Hill and Trig. Station, No. 18, and for some considerable distance further; occupying, in all, a distance of about three miles. The quartz schist has a steep dip to the East.

The most important structural feature is the system of basic dykes with which the whole area is seamed. These dykes have no apparent connection with any visible deep-seated rock of similar composition. The basic dykes exhibit, when their trend is laid down upon a map (Plate iii.) with some degree of accuracy, a remarkable parallelism, having a general trend of North-East and South-West, or, approximately, at right angles to the sheeted zones above mentioned. The longest has been traced across country without interruption for a distance of over 10 miles, and extends both North and South far beyond the limits of the country examined. The breadth varies much in different places, but in no case was the width exposed on the surface very great. Wherever any sections were visible the dykes were either vertical or inclined at very high angles. The rocks of which the dykes are composed are all basic compounds, and have a specific gravity of 3·07.

Over the whole of the Northampton District there is not a mine which has been sunk to any great depth, and operations ceased when the lodes showed signs of cutting out. The lodes of lead and copper, which have already been opened up, are parallel to the basic dykes. Igneous dykes of this nature represent what were originally fractures in the earth's crust, which pass downwards to very considerable depths, and the lodes fill in fissures of a similar character which find their origin far below the limit of practical mining. The lodes, in consequence, will continue downwards as far as ever operations are likely to be carried. The method of the formation of fractures and the movement of either of the walls have the effect of producing alterations in the nature of the fissures by forming wide or narrow portions, which have been subsequently filled with ore. There must always be local variations in the metallic contents of ore bodies, but there are no scientific grounds for believing that the mines of this district have reached the limits of ore deposition, and that the ore bodies will not prove equally productive when followed either horizontally or vertically. As the deposition of ore bodies is most intimately connected with the system of fracturing to which the district has been subject, it is evident that the search for further lodes must follow that direction which the evidence already accumulated has shown to be that of greatest ore deposition; and this direction is that which lies parallel to the system of basic dykes. Judicious prospecting carried out upon these lines should result in the discovery of other lodes equally productive to those already exploited.

Mining appears first to have commenced in the year 1842, and, since that date up to the end of 1899, 12,677 tons of copper ore, valued at £208,298, and 33,617 tons of lead ore, valued at £364,514, have been exported from the Colony. Of this quantity 43,407 tons may be credited to the Northampton District.

Appended will be found several tables showing the quantity of copper and lead ore exported from the Colony since 1850. The first shipment of ore from the district is said to have taken place during the year 1845; but no details as to either the quantity or the value are available. These tables do not show the actual quantity of metallic lead and copper produced from the ore. It is, however, desirable that, in future statistics, this information should be supplied.

Whim Well.

The Pilbarra District seems to be very rich in ores of copper, the most important locality being at Whim Creek. The district has been visited and reported upon some years ago by Mr. H. P. Woodward, who states that:—

The mine is situated upon the North-West Coast, about 50 miles to the Eastward of Roebourne, near Mount Negri, and when it is stated that it was worked by about four men for a month or two in 1890, and that, from the results, the syndicate were able to pay all the working and preliminary expenses, some idea can be gained of the richness, size, and quality of the lode. . . . The lode is on the surface, forming the face of a low ridge running East and West for about half-a-mile, when it is lost at both ends. It dips gently to the North at an angle that allows it to be worked comfortably on the footwall, *i.e.*, with just sufficient pitch to allow masses to be rolled down, and yet not too steep for men to work upon it. It is 12 feet in thickness where it has been opened, 6 feet of which can be dressed without the slightest trouble to 30 per cent., and with care even to 40 per cent., whilst the other 6 feet can be dressed to 20 per cent. with a little trouble, and if a proper dressing plant were erected better results could be obtained. The lode appears to be good in quality throughout its entire length, and is nowhere, as far as can be judged from the surface, less than 6 feet in thickness, and most of it is a good deal more. The ore consists of the liver-coloured mixture of oxides and carbonate, chiefly green, but there is some blue also in the poorer parts of the lode, while, in the rich, some beautiful specimens of malachite have been obtained, and some large slugs of native copper.

Roebourne.

Some copper workings were opened a few years ago a little South of Roebourne. They are situated at a base of some low slate and quartzite hills on the edge of a large flat formed by one of the branches of the Harding River. These lodes are chiefly oxides of iron and copper, in some of which gold is visible. There are two sets of lodes, one running more or less North and South and dipping East, while the other runs East and West and dips North. . . . . Large ferruginous copper lodes occur all over this district, some of which carry from 30 to 40 per cent. of copper ore, but the mass of the lode stuff is iron. In some of the specimens gold is plainly visible. . . . .

The following table shows the production of copper ore from the North-West so far as can be judged by the records of the Customs House:—

Production of Copper Ore from the Pilbarra District.

Year.	Ore Exported.			Value of Ore.		
	tons	cwt.	qrs.	£	s.	d.
1891	262	0	0	(not available)		
1892	412	0	0	do.		
1893	50	0	0	606	0	0
1894	*Nil*			...		
1895	802	0	0	12,832	0	0
1896	6	6	0	100	0	0
1897	64	17	0	731	5	0
1898	280	17	0	3,335	0	0
1899	1,404	0	2	31,979	0	0
Total ...	**3,282**	**0**	**2**	**48,983**	**5**	**0**

Other Localities.

In the Kimberley District some very fine copper ores exist. They are associated with small quantities of gold. The geographical position of the deposits is, however, at present, a bar to their successful working.

Lodes of lead and copper are also known to occur in the country between Arrino Springs and the Irwin River, in the Yandanooka mining district. No details in connection with these, however, are available.

Copper also occurs in the Wongan Hills, disseminated in varying quantities through ordinary quartz reefs. The reefs have a strike coincident with that of the enclosing schists, viz., North and South. As a general rule the quartz is of a somewhat white sugary appearance, which carries hematite, limonite, azurite, malachite, and oxide of copper, together with actinolite, serpentine, and garnets. The oxides of iron are disseminated through the quartz in the form of grains as well as irregular veins traversing the quartz. Assays have been made in the official laboratory of different portions of the quartz reefs, with the result that gold to the extent of 1dwt. per ton was obtained, and copper from 8 to 16 per cent.

Copper ores are also known near Middle Mount Barren, on the South Coast, in the Phillips River mining district; but as no geological examination has been made of the district, details as to their mode of occurrence and other cognate points are not available.

The following tables give the production of the ores of lead and copper of the Colony as well as that of pig lead, as shown by the archives of the Collector of Customs:—

The Production of Copper Ore in Western Australia.

Year.	Ore Exported.			Value of Ore.			Year.	Ore Exported.			Value of Ore.		
	tons	cwt.	qrs.	£	s.	d.		tons	cwt.	qrs.	£	s.	d.
1855	2	0	0	26	0	0	1878	9	0	0	135	0	0
1856	57	0	0	1,018	0	0	1879	...			...		
1857	80	0	0	1,920	0	0	1880	8	0	0	120	0	0
1858	433	0	0	9,531	0	0	1881	...			...		
1859	941	0	0	14,122	0	0	1882	1	10	0	22	0	0
1860	517	0	0	8,021	0	0	1883	5	0	0	75	0	0
1861	409	0	0	6,339	0	0	1884	118	0	0	1,770	0	0
1862	783	0	0	12,536	0	0	1885	119	10	0	1,792	0	0
1863	760	0	0	12,208	0	0	1886	249	0	0	3,735	0	0
1864	1,076	0	0	17,216	0	0	1887	23	0	0	345	0	0
1865	886	0	0	13,290	0	0	1888	87	10	0	1,487	10	0
1866	337	0	0	5,055	0	0	1889	112	0	0	1,904	0	0
1867	557	0	0	8,362	0	0	1890	8	0	0	136	0	0
1868	83	0	0	1,245	0	0	1891	262	0	0	4,463	10	0
1869	155	0	0	2,325	0	0	1892	567	0	0	8,696	0	0
1870	6	0	0	90	0	0	1893	50	0	0	606	0	0
1871 to 1872	*Nil*			...			1894	No data					
							1895	826	0	0	12,952	0	0
							1896	6	6	0	100	0	0
1873	56	10	0	847	0	0	1897	86	0	0	1,033	0	0
1874	66	10	0	998	0	0	1898	355	8	0	4,266	0	0
1875	255	0	0	3,071	0	0	1899	1,991	5	0	41,452	0	0
1876	279	0	0	4,185	0	0							
1877	53	10	0	802	0	0							
							Total	**12,677**	**9**	**0**	**208,297**	**10**	**0**

The Production of Lead Ore in Western Australia.

Year.	Ore Exported.			Value of Ore.			Year.	Ore Exported.			Value of Ore.		
	tons	cwt.	qrs.	£	s.	d.		tons	cwt.	qrs.	£	s.	d.
1850	5	0	0	55	0	0	1875	2,289	0	0	27,468	0	0
1851 to 1852	*Nil*			...			1876	2,191	10	0	26,298	0	0
							1877	3,955	10	0	47,466	0	0
							1878	3,617	10	0	43,410	0	0
1853	*a*			4	0	0	1879	2,775	0	0	33,300	0	0
1854	*Nil*			...			1880	1,921	0	0	15,368	0	0
1855	25	0	0	250	0	0	1881	1,400	10	0	11,204	0	0
1856 to 1858	*Nil*			...			1882	1,793	10	0	14,348	0	0
							1883	1,038	0	0	7,266	0	0
							1884	696	0	0	4,872	0	0
1859	13	10	0	135	0	0	1885	465	0	0	3,255	0	0
1860	98	10	0	985	0	0	1886	611	0	0	4,277	0	0
1861	79	0	0	790	0	0	1887	471	0	0	4,710	0	0
1862	9	0	0	90	0	0	1888	532	0	0	5,320	0	0
1863	230	0	0	2,300	0	0	1889	250	0	0	2,500	0	0
1864	80	0	0	800	0	0	1890	213	10	0	2,135	0	0
1865	703	0	0	8,436	0	0	1891	25	0	0	250	0	0
1866	273	10	0	3,282	0	0	1892	29	15	0	150	0	0
1867	902	0	0	10,824	0	0	1893 to 1896	*Nil*			...		
1868	1,100	10	0	13,206	0	0							
1869	699	10	0	8,394	0	0							
1870	1,209	10	0	14,514	0	0	1897	*a*			4	0	0
1871	420	0	0	5,040	0	0	1898	5	0	0	33	0	0
1872	364	0	0	4,368	0	0	1899	16	0	0	96	0	0
1873	965	10	0	11,586	0	0							
1874	2,143	15	0	25,725	0	0	Total	**33,617**	**0**	**0**	**364,514**	**0**	**0**

a No tonnage given. Declared at £4.

Export of Pig Lead from Western Australia.

Year.	Pig Lead Exported.			Value of Pig Lead.		
	tons	cwt.	qrs.	£	s.	d.
1853	55	0	0	1,200	0	0
1854	122	0	0	2,440	0	0
1855	133	15	0	2,675	0	0
1856	60	0	0	1,200	0	0
1857	120	10	0	2,410	0	0
1858	61	0	0	1,220	0	0
1859	24	15	0	495	0	0
1860 to 1866	No data			...		
1867	*a* 3	0	0	50	0	0
1868 to 1874	No data			...		
1875	4	5	0	89	5	0
1876	*a* 7	0	0	155	0	0
1877	*a* 1	0	0	15	0	0
1878 to 1879	No data			...		
1880	*a* 5	0	0	89	0	0
1881	*a* 1	0	0	20	0	0
1882 to 1886	No data			...		
1887	*a* 6	0	0	120	0	0
1888	*a* 2	0	0	40	0	0
1889 to 1896	No data			...		
1897	*b* 0	10	0	11	0	0
1898	No data			...		
1899	77	0	0	1,077	0	0
Total ...	**683**	**15**	**0**	**13,306**	**5**	**0**

a No tonnage given. Estimated.
b No tonnage given. Six packages estimated at 10 cwts.

CHAPTER VI.

TIN.

General.—Greenbushes, Pilbarra, and Kimberley.

Tin has been discovered in three widely-separated localities in the Colony, viz., at the heads of the Bow and the Lennard Rivers, in the Kimberley District; at Brockman's Soak and the Western Shaw, in the Pilbarra District; and at Greenbushes, in the South-Western portion of the Colony. Mining operations have been most active at Greenbushes; a little has been done at Pilbarra but, so far as official information goes, no prospecting seems to have been carried out

Greenbushes.—The discovery of tin at Greenbushes would seem to have been due to the researches of the late Mr. E. T. Hardman, a former Government Geologist. This gentleman, while engaged upon official duties in the Blackwood District, was accompanied by

a Mr. Stinton, to whom Mr. Hardman suggested the probable occurrence of tin-bearing deposits. Having this in mind, Mr. Stinton, at the conclusion of the journey, returned to Greenbushes, and after a time eventually discovered the rich stream deposits worked by a Bunbury syndicate.

The Greenbushes Tinfield, as defined by the authorities, is situated on the comparatively lofty tableland drained by the heads of Norilup and Hester's Brook. The highest point of this tableland is 900ft. above sea level, and is crossed by the main road from Bridgetown to Donnybrook.

The surface of this tableland is hilly and broken, but to the South-Westward the creeks open out into large swampy flats, which are drained by steep rocky channels into the Blackwood River. The field is connected with the main railway system of the Colony.

The salient geological features have been described by Mr. H. P. Woodward in 1891, who wrote that "the formation of the district consisted for the most part of crystalline rocks (of the age of which the district affords no clue), alluvial deposits, and the ferruginous conglomerate, which covers by far the larger portion of the tinfield." The crystalline rocks consist chiefly of gneissose and granitic rocks, intersected by dykes of diorite, tourmaline granite, and schorl-rock. All the rocks have a general North and South strike. The area which these rocks occupy on the surface can be seen on the small scale-map herewith.

The tin deposits of Greenbushes fall naturally into two distinct categories:—

Superficial Deposits:

(*a.*) Alluvial deposits.
(*b.*) Residuary sands, gravels, etc.

Deposits in Country Rock:

(*c.*) Tin-bearing granite.
(*d.*) Tin-bearing dykes.

(*a.*) *Alluvial Deposits.*—These are found flanking the course of all the existing watercourses; their extent has been accurately delineated upon the geological map Plate II., from which it can be readily seen that they do not cover a relatively large area. The alluviums do not attain any very great thickness, but a fairly large proportion of tin has been derived from these deposits. The whole of these modern alluviums are not tin-bearing; the richest seems to be that formed by Spring Gully and its tributaries. A great deal of work has been accomplished in Spring Gully, and more especially on the tributaries entering it on the North. The deposit in Spring Gully consists of two distinct portions:—

(1.) An upper, or "free dirt," *i.e.*, loose gravel; and
(2.) A lower, stiff, "clayey dirt," containing irregular bands of detrital tin.

The free dirt, which varied from one to three feet in thickness and about 18 to 20 yards in width, proved exceptionally rich in tin. The physical character of some of the tin shows that it can only

have been released from the parent rock in close proximity to where it is at present found. No small portion of it has been derived from the denudation of the granite belt, reticulated with tin-bearing veins, which crosses Spring Gully from North to South.

An older alluvium is exposed in what is known as Elliot's Gully, a tributary of the Bunbury, and has been extensively worked at different times. The "wash" lies at 50 feet from the surface. The wash is a very coarse conglomerate, with a very large proportion of flat-sided boulders, cemented together in part with oxide of iron. The conglomerate or cement, which has an average thickness of about two feet, shows tin freely. Directly overlying the cemented wash is a fairly extensive deposit of white, gritty sand, which contains a relatively large proportion of detrital tourmaline. The floor upon which the deposit rests consists of vertical decomposed clay-slates, which strike South-East and North-West.

(*b*.) *Residuary Sands, Gravels, etc.*—In addition to the alluvial deposits, by far the larger portion of the field is covered with a mantle of very variable thickness of sands, gravel, and conglomerate. These deposits are not of an alluvial character, but owe their origin to the decomposition *in situ* of the underlying rocks. The sands unite in giving what is practically a uniform section, which consists of from two to three feet of peaty soil, succeeded by a very variable thickness of white, gritty sand, carrying varying proportions of mica, tourmaline, and occasionally tin. These sands result from the residual decomposition of a granitic rock, which may or may not be reticulated with tin-bearing veins.

One of the most noticeable features in the structural geology of Greenbushes is the ferruginous conglomerate and gravel, the position of which has been accurately delineated upon the geological map attached. In its mode of occurrence the conglomerate presents one important feature, viz., that it does not form a horizontal table-land, but occurs at different elevations, and seems to have adapted itself to the original contour of the ground upon which it originated. The conglomerate covered a much larger area than it at present occupies, and denudation has gone on to a large extent since it formed part of one continuous formation. The thickness of the conglomerate is nowhere very great, operations having shown that it rarely, if ever, exceeds 20 feet. The conglomerate is not of sedimentary origin, but has apparently been formed by the alteration *in situ*, and subsequent cementation of the underlying rocks. In some portions of the field this conglomerate (as is only to be expected from its mode of origin) carries a certain quantity of tin. The ore, however, is not evenly distributed throughout, but seems to be concentrated in certain comparatively isolated patches. The tin from this conglomerate cannot be extracted by the ordinary process of washing without milling. Like alluvial deposits, these residuary gravels and conglomerates are evanescent, and can be exhausted.

Both the modern alluviums and the residuary sands, gravels, and conglomerates have yielded by far the greater portion of the

tin turned out from Greenbushes. It by no means follows that the richness of these is proof of exceptionally rich lodes or veins beneath; for, owing to the extreme difficulty with which certain minerals are acted upon by atmospheric agencies, they often remain to gradually accumulate in much greater quantity than existed in the parent rock. It is to this natural process of concentration that the richness of the superficial accumulations of Greenbushes is due.

(*c.*) *Tin-bearing Granite.*—The tin-bearing granite consists of a granite passing in places into a foliated and highly-micaceous granite, with little or no felspar. This granite (greisen) contains tin, tourmaline, zircon, garnet, etc., as accessory constituents. In some parts of the field the tourmaline occurs in such quantity in the gneiss as to give a distinctive character to the rock, and would be better described as a tourmaline gneiss. Some specimens of this highly micaceous rock from Caporn's Deep Shaft, now known as the Cornwall, yielded on assay in the official laboratory tin to the extent of 1·79 parts per hundred. A "tin floor" has been worked at the head of Spring Gully on an old lease (82/244), at a depth of 16 feet from the surface. The floor, a tin vein, was found underlying at a low angle to the North-West. The vein had been followed for about 40 feet to the rise, *i.e.*, South-East. The tin, which is associated with tourmaline, quartz, and a little mica, is confined to a zone of about one foot in thickness. The country rock is a decomposing granite. On the Southern bank of Bunbury Gully, not far from its head, another well-marked "tin floor" has been worked at a depth of about 30 feet from the surface. The "floor" underlies at a low angle to the West. The material forming the floor, locally spoken of as "wash," is about 2 feet 6 inches in thickness, and consists of mica, quartz, a little tourmaline and tin. The deposit occurs within the zone of decomposition of the tin-bearing granite.

The tin-bearing granite occupies a definite and fairly well-defined belt, trending approximately North-West and South-East from Hester's Troughs, Bunbury Gully, across the heads of Dumpling Gully, and a little to the East of Horan's claim; it includes Bishop Gibney's ground, the heads of Spring Gully and Cowan Brook. This direction coincides with that along which lines of weakness have been produced by earth movements of considerable intensity; it is along these fractures that mineral-bearing solutions have penetrated and deposited the tin. This granite has been reticulated by a number of tin-bearing veins, forming a stock-work, and many have already been worked in the zone of surface decomposition as alluvial deposits. This area is not, however, coterminous with the legal boundaries of the field; the continuation of the tin-bearing belt should be looked for in both a North and South direction. The presence of the ubiquitous conglomerate, however, would render prospecting on the North most difficult. The best localities to search for further deposits would be along lines of greatest erosion, and that is in the vicinity of the present water-courses.

(d.) Tin-bearing Dykes.—These occur in several parts of the field. One of the most typical occurs on the Eastern side of the main Bridgetown Road, upon what was originally M.L. 82/76. A shaft had been put down to a shallow depth upon a tourmaline-bearing dyke, which was met with beneath the conglomerate at a depth of about 5 feet below the surface. The conglomerate contains detrital tourmaline, which led to the discovery of the dyke. As exposed in the workings, the width of the dyke is about 2 feet 6 inches, having a general North-Westerly strike, with an underlie to the South-West at an angle of 70°. The tourmaline is enclosed in a ferruginous clayey matrix, which contains occasional patches of quartzose material; the dyke may be a tourmaline-bearing pegmatite. The rock contains a small quantity of very angular tin, associated with large quantities of titanium. The tourmaline itself carries in parts appreciable quantities of tin. An assay of a carefully-selected sample, believed to be characteristic of the whole dyke, yielded in the official laboratory 1·97 parts per hundred of metallic tin. There are several other parallel dykes throughout the field, but, so far, they have not been very much exploited, and do not appear to be very rich.

Whatever doubt there may have been as to the occurrence of ore deposits, other than superficial accumulations, has been definitely set at rest. The ore bodies are not lodes within the strict meaning of the term, but are merely a network of irregular tin-bearing veins distributed over a fairly well-defined area. Such deposits, which owe their origin to deep-seated sources, are as likely to be as permanent as anything in the nature of such ever can be. It, however, by no means follows from this that any individual vein can be followed laterally or vertically for any great distance, but each vein will give place to another, and so on.

Owing to the extremely low assay values of many consignments of what seemed to be perfectly clean tin ore, which has been shipped from the district, attention has been naturally directed to the mineralogical characteristics of the ore. It was found that associated with the tin was a mineral of about the same specific gravity as cassiterite, rendering it almost impossible to separate the two mechanically. These investigations confirmed those made by Mr. G. A. Goyder, the Government Analyst of South Australia, in 1898, whose analysis showed the foreign mineral to be essentially a tantalate of antimony, of the following composition:—

Tantalic Oxide, Ta_2O_5	51·13
Niobic Oxide, Nb_2O_5	7·56
Antimony Trioxide, Sb_2O_3	40·23
Bismuth Trioxide, Bi_2O_3	·82
Nickel Protoxide, Ni O...	·08
	99·82
Specific gravity	7·37

A complete analysis of marketable ore assaying low in tin was made in the Departmental Laboratory, with the following result:—

Loss on ignition	·22
Tin Dioxide, $Sn\ O_2$	53·14
Titanic Oxide, $Ti\ O_2$	·67
Silica, $Si\ O_2$	1·61
Ferric Oxide $Fe_2\ O_3$	4·11
Alumina, $Al_2\ O_3$	·42
Manganese Protoxide, $Mn\ O$	1·61
Lime, $Ca\ O$	·69
Magnesia, $Mg\ O$	·39
Antimony Trioxide, $Sb_2\ O_3$	15·13
Bismuth Trioxide, $Bi_2\ O_3$	Trace
Tantalic Oxide, $Ta_2\ O_5$	19·85
Niobic Oxide, $Nb_2\ O_5$	3·56
	101·40
Metallic Tin	41·80

Owing to the fact that Antimony Oxide tends to form an extremely impure tin alloy, a considerable loss of tin might result in refining. Doubtless this drawback can be overcome when the properties of the mineral (stibio-tantalite) have been properly investigated. The occurrence of this mineral may be held to explain why some of the returns to the vendors of tin ore have fluctuated so considerably.

Since the year 1891, mining has been carried out in somewhat desultory fashion, and, considering all things, a fair quantity of tin has been raised, as disclosed by the records kept in H.M. Customs House. These figures until quite recently were the only data available for arriving at the yield of the Greenbushes Tinfield, which is shown in the following table:—

Export of Tin Ore from the Greenbushes Tinfield.

Year.	Ore exported.			Estimated Value.			Remarks.
	tons	cwts.	qrs.	£	s.	d.	
1891	204	0	0	10,300	0	0	The Mining Registrar at Greenbushes reports :—"Of previous years there is no record either at Bunbury or Fremantle, and I believe the amount to be inconsiderable."
1892	265	9	3	13,843	0	0	
1893	171	10	0	7,664	0	0	
1894	371	5	0	14,325	0	0	
1895	277	3	0	9,703	0	0	
1896	137	5	0	4,338	0	0	
1897	95	11	0	3,275	0	0	
1898	68	2	3	2,760	0	0	
1899	278	8	1	21,138	0	0	
Total	**1,868**	**14**	**3**	**87,346**	**0**	**0**	

Pilbarra.—"Tin has also been found in the alluvial workings at Pilbarra . . . . A very rich deposit of coarse stream tin occurs near Messrs. G. & J. Withnell's station on the Shaw, which assayed 71 per cent. of metallic tin . . . ."*

No geological examination of the district having been made, no further information is available.

Tin has also been worked in 1899 on the Coongan River, about 10 miles South of Marble Bar. The country is said to be very favourable for the occurrence of tin deposits.

The following table gives the yield of the Pilbarra District, so far as can be judged by the Customs records:—

Export of Tin Ore from Pilbarra.

Year.	Ore exported.			Estimated Value.			Remarks.
	Tons	cwt.	qrs.	£	s.	d.	
1893	56	9	0	3,470	0	0	
1894	19	0	0	949	0	0	
1895 } 1898 }	0	0	0	0	0	0	
1899	29	11	0	2,025	0	0	
Total	**105**	**0**	**0**	**6,444**	**0**	**0**	

Kimberley.

Oxide of Tin is known to occur in the gravels at the heads of the Bow and the Lennard Rivers, but no details are available.

The table below gives the export of tin ore from the Colony.

The Production of Tin in Western Australia.

Year.	Tin Ore exported.			Estimated Value.			Remarks.
	tons	cwt.	qrs.	£	s.	d.	
1889	5	0	0†	300	0	0	† The Collector of Customs reports:—"In all probability the produce of the Greenbushes Tinfield."
1890	67	10	0†	5,400	0	0	
1891	204	0	0	10,300	0	0	
1892	265	9	3	13,843	0	0	
1893	227	19	0	11,134	0	0	
1894	390	5	0	15,274	0	0	
1895	277	3	0	9,703	0	0	
1896	137	5	0	4,338	0	0	
1897	95	11	0	3,275	0	0	
1898	68	2	3	2,760	0	0	
1899	307	19	1	23,163	0	0	
Total	**2,046**	**4**	**3**	**99,490**	**0**	**0**	

* H. P. Woodward. *Loc. Cit.*

CHAPTER VII.

IRON ORES.

General.—Analyses of Western Australian Iron Ores—Kimberley, Horseshoe Range, Weld Range, Mount Narryer Range, Mount Taylor, Mount Hale, Mount Gould, Coolgardie, Coates' Siding and Mount Baker, Greenbushes, Wongan Hills. Meteoric Irons—Production of Iron Ore.

The ores of iron are extremely widely distributed throughout Western Australia, yet, with one or two exceptions, the area in which the exploitation of such deposits is actively prosecuted is very limited; a condition of affairs for which the distance from market, and the comparatively low price at which iron can be landed in the Colony, may be held accountable. Some of the richest and most extensive iron deposits are absolutely valueless, owing to their geographical position; a condition of affairs which increased facilities for transport might rectify.

The iron deposits of the Colony, so far as our present knowledge is concerned, can be broadly separated into two main divisions—a grouping which is based in part upon their chemical composition, and in part upon their mode of occurrence:—

(*a*.) The ores associated with the crystalline schists and other allied rocks; and

(*b*.) The superficial deposits of limonite which occupy such extensive areas in many parts of the Colony, and for which the Indian term Laterite Ore, or the Roche à Ravets of French Guiana (with which the deposits are comparable) would be appropriate.

The following table shows the results of the analyses of certain of the iron ores of the Colony, as made in the Departmental Laboratory:—

Table of Analyses of Western Australian Iron Ores.

Nature of Ore.	Locality.	Analysis.	
		Metallic Iron per cent.	Other Determinations.
Concretionary Ironstone (Laterite)	Mt. Baker ...	51·33	Manganese monoxide, trace; silica, 4·44°/o.
Do.	Do. ...	50·54	Manganese monoxide, trace; silica, 5·49°/o.
Do.	Darling Range	34·73	Manganese monoxide, *nil;* silica, 19·44°/o.
Do.	Do. ...	45·00	Manganese monoxide, trace; silica, 9·88°/o.
Do.	Do. ...	41·60	Manganese monoxide, trace; silica, 11·33°/o.
Do.	Do. ...	59·63	Manganese Monoxide, 0·35°/o; silica, 1·59°/o.
Do.	Do. ...	66·96	Silica, 2·21°/o.
Magnetite	Collie District	64·48	
Turgite (Laterite) ...	Greenbushes ...	62·47	
Argillaceous Ironstone (Lodestuff)	Wiluna ...	35·5	
Hematite	4 miles N.-W. of Munara Gully, Murchison G.F.	63·7	
Do.	Bardoc (G.M.L. 2534)	55·5	
Concretionary Ironstone (Laterite)	Menzies ...	28·2	
Limonite	Mt. Jackson ...	53·0	
Siliceous Hematite ...	Mt. Narryer ...	56·7	
Hematite	Mt. Hale ...	65·8	
Clay Ironstone (Laterite)	Coolgardie (G.M.L. 2843)	25·13	

Kimberley.—The sandstones of the Upper Carboniferous Series of Kimberley abound in nodular and spheroidal masses of hematite. Spheroids fully 6ft. in diameter have been noticed at Duke's Dome, to the South of the Fitzroy River. "Some of these nodules, whether of the size just mentioned, or only a few inches in diameter, consist of a nucleus of sandstone coated with a more or less pure hematite. Sometimes the sandy interstice is quite soft, and then on breaking the specimens this falls out, and the result is a hollow shell. But more often the iron deposit adheres closely to a firm nucleus of grit. The ironstones are often a black carbon colour, due to the presence of magnetic iron sand. When the rock is powdered, this can easily be extracted by means of a magnet. Commercially these iron ores are of no value, as in general the amount of metallic iron is low, and even if

they were of the best quality they would hardly pay for the labour of extracting them from the rock." * Thick veins of iron ore have been noticed in the limestones of the Rough Range, and in the sandstones to the East of the Mount Elder Range.

"The quantity of iron disseminated throughout the various rock formations of Kimberley is something enormous, and the deposits often assume most fantastic forms; thus, to the South of the Grant Ranges, near the Fitzroy River, there are low hills of carboniferous sandstone; on the surface of which rock, and on the lower ground are strewn quantities of large pieces of rusty ironstone, exhibiting a great variety of artificial looking structure. Some of these specimens show on the surface most intricately folded and twisted patterns, while others resemble the metal framework of a lattice church window." †

Horseshoe Range.—The Horseshoe Range, which is virtually a combination of that low line of hills extending from the township of Peak Hill, is composed of hematite-bearing quartzites, of the type described below, which dip at a high angle to the West. The outcrop of the iron-bearing series forms the most conspicuous feature in the range, and is visible for great distances. These beds are of interest, in that some of them have proved to be highly auriferous.

Weld Range.—In the Weld Range, at the head of the Roderick River, is the celebrated Wilgie Myah, said to be probably one of the richest iron lodes in the world. The deposit consists "almost entirely of hematite, which, at the surface, and in the cavities, assumes the botryoidal form, which has given rise to the idea that it is a lava flood. It is situated on the East side of the Weld Range, and runs East and West dipping North, following the main strike of the rock. In these lodes there are soft bands, often clayey. These the kangaroos scratch out, forming caves, and it is probably in this way that the natives first made the discovery that this lode could be easily worked by following these beds. It has now been opened up as a huge pit or quarry, to a depth of about 100 feet. This is entered near the top of a hill (about 70 or 80 feet above the plain) by a hole about 50 feet across; then a steep descent commences over the talus in a South-Easterly direction. At the bottom it spreads out to about 50 yards wide, with the roof some 50 feet above, and numerous cave-like galleries running into the face in all directions. "The Wilgie is worked by cutting round a mass of it, then wedging it off. This work, though very primitive, is very interesting, as the natives work with their wooden tools much in the same way that the ancient miners did in Great Britain with stone hammers. There are also rude attempts at staging, to allow the miners to work up into the roof, when veins of sufficiently good quality run that way. "In contemplating this pit one is struck by

* The Geology of the Kimberley District, Western Australia; E. T. Hardman, Perth: By Authority: 1884; p. 9.

† On the Geology of the Kimberley District, Western Australia; E. T. Hardman, Perth; By Authority: 1885; pp. 33-34.

the vastness of the work, and when we consider the small quantity of Wilgie that can be required, it must have been worked for centuries. Of course it was worked on a much larger scale before the white invasion of Western Australia, and was probably traded great distances. As far as the lode itself is concerned it is most magnificent iron ore, and considering its size will, without doubt, be of great value in the future."*

Mount Narryer Range.—The outcrop of a bed of ironstone forms a conspicuous feature on the surface at the foot of the Mount Narryer Range. The bed is vertical; it trends North-North-East, attains a thickness of eight or nine feet, and rises about two feet above the ground. Similar beds of ironstone occur in other portions of the range; they are interbedded with and can sometimes be seen replacing quartz schists. An assay of one of these hematite-bearing schists (338) from Mount Narryer, in the Survey laboratory, yielded 81·03 per cent. of ferric oxide.

Mount Taylor.—That sigmoid-shaped range of hills on the West of the Murchison River, of which Mounts Taylor, Hale, Matthew, Yarrameedie, and Erawandoo form the most prominent summits, is particularly prolific in iron-bearing schists. Just under the summit of Mount Hale, the quartzite is replaced by an enormous bed of hematite, several huge monoliths of which stand out prominently on the range. The trend of this hematite can be followed by the eye along the range just to the South of the summit of Mount Matthew. An assay of a sample of this bed yielded the following composition:—

Ferric Oxide, Fe_2O_3	... ...	94·05%
Ferrous Oxide, $Fe\,O$	... ...	0·97%

Mount Hale.—The summit of Mount Hale is formed of contorted quartzites or quartz schists, with bands of hematite, which occur in lenticular masses; some bands are often as thin as a sheet of paper, whilst others gradually widen out to enormous dimensions. One band measured 70 feet across, and outcropped for over a quarter of a mile, but varied in thickness in different parts. There were similar bands to it, and equally persistent along the strike.

Mount Gould.—The *massif* of Mount Gould lies to the North of Mount Matthew. Its flanks and summit are composed of iron-bearing schists. One conspicuous band forms the summit of Mount Gould. The hematite occurs in what may be aptly described as a modified laccolite form.

Coolgardie.—In the course of the Geological Survey of Coolgardie it has been found † that semi-detached patches of ironstone gravel, trending generally North and South, lie at a somewhat uniform level between 1,380 and 1,460 feet above sea level. The dissemination of the ferruginous matter derived from these ironstone beds is accountable for the red colour of the alluvium and other

* The Murchison Goldfield. H. P. Woodward, Perth; By Authority: 1893; pp. 20, 21.

† The Geology of the Coolgardie Goldfield. Torrington Blatchford. Bulletin No. 3, Perth; By Authority: 1899; pp. 35-36.

superficial accumulations by which the deposits are surrounded These ironstone gravel beds vary from a few inches up to 15 feet in thickness. The ferruginous clays have been altered *in situ* into ironstone nodules, which pass upwards into hard ironstone pebbles, these latter have in places been cemented together, forming compact pure ironstone. An analysis of a fairly typical sample, from near Retribution Gold Mining Lease 2483, yielded, in the official laboratory, the following percentage composition:—Ferric Oxide 32·25, Ferrous Oxide 00·51, which is equivalent to 25·07 per cent. of metallic iron. It is interesting to note that some of these gravels yielded on assay from 5 to 8dwts. of gold per ton.

Coates' Siding and Mount Baker.—In these localities, which are about 40 miles from Perth, there is a very large area of a ferruginous conglomerate, which analyses have shown to contain an average of about 12 per cent. of iron. The surface of the ground occupied by the conglomerate is generally covered with a glazed crust of limonite (hydrated oxide of iron) of a reddish-brown hue. A freshly broken surface shows the rock to be mottled with different shades of brown or yellow, and sometimes red. Some varieties occur in the form of pisolitic nodules of small size, and in other cases there are irregular cavities between each individual nodule. Exceptional portions of the rock are brecciated, and contain angular fragments of limonite, in a ferruginous clayey matrix. The area which the deposit covers is extensive; the character of the conglomerate is virtually the same throughout, but in one or two places what may be called the ironstone-breccia form occurs, but it appears to be merely local. The thickness of the deposit has so far not been proved; one excavation due North of the railway line has penetrated the conglomerate to a depth of 10 feet without reaching the underlying rocks. An analysis of what may be termed an average sample of the ore yielded only 12·1 per cent. of iron, whilst an exceptional portion returned 44·2 per cent. of metallic iron.

Greenbushes.—About two thousand tons of limonite (laterite ore) have been raised from a deposit occurring on the North of the railway station, and it has been used for fluxing purposes at the Fremantle Smelting Works.

Wongan Hills.—An extensive deposit of what may be called a lateritic limonite forms a very noticeable feature in the neighbourhood. The deposit originally covered the whole of the Wongan Hills, but extensive denudation has taken place and the iron ore formed part of one continuous formation. The lithological character of the deposit presents all gradations from a ferruginous claystone to pure limonite; the former, however, predominating. The rock itself is very porous, and weathers very readily into caverns and cavities of all sizes, whilst the surface of the rock is covered with a glaze of hydrated oxide of iron of a reddish-brown colour in places. A gradual passage can be noticed in places, from a pure ferruginous claystone to pure limonite. Of the origin of the deposit, it is difficult, with the present meagre evidence to hand, to form any satisfactory opinion. It is not a sedimentary deposit, and as it

passes by insensible gradations into the underlying rocks without any sharp line of demarcation, its formation would seem to have been due to the alteration *in situ* of the rocks beneath, and to the residual concentration of iron oxides by the action of atmospheric changes. The deposit, by reason of the ease with which it could be smelted rather than its richness or purity, might become of some considerable importance were it in a more favourable geographical position.

METEORIC IRONS.

Meteoric Irons are also known in the Colony, but they are more of scientific than of commercial interest. Reference having been made to these in scientific publications not readily accessible in the Colony, it has been deemed advisable to include a brief account of these in connection with the terrestrial iron ores.

Youndegin.—In the month of January, 1884, fragments of a meteorite were discovered at a spot three-quarters of a mile North-West of the summit of Penkarring Rock, in the Youndegin District, about 70 miles East of York. The fragments, four in number, were lying loose on the surface, three of them close together, and the fourth about 15 feet away; they weighed $25\frac{3}{4}$lbs., 24lbs., $17\frac{1}{2}$lbs., and 6lbs. respectively. The pieces seem to have formed portions of a spherical mass. Scattered around the iron were broken pieces (of which 17lbs. were collected) apparently belonging to a shell or outer covering; these consisted of magnetic oxide of iron, and may have been due to the weathering of the meteorite. The vicinity of Youndegin consists of granite and schist, intersected by dykes of quartz, and overlaid in places by a superficial covering of sandstone. The fact that iron ore does not occur near Youndegin would seem to indicate an extra-terrestrial origin for the fragments. The meteorite was analysed by Mr. L. Fletcher, late Keeper of Minerals, British Museum, and found to have the composition shown in the Table 1. The specific gravity, as determined from three small pieces freed from rust, was found to be 7·86, 7·85, and 7·72 respectively. The insoluble cubes on further examination proved to be a form of carbon, like graphite, with which it had characters in common, except form and hardness. To this form of meteoric graphite the name of Cliftonite has been applied.* In addition to this there occurred small quantities of a magnetic mineral in the form of small, thin, lustrous black plates. An analysis showed it to be an alloy of nickel and iron, belonging to the tænite group.†

In 1891 a new meteorite was discovered in the vicinity of Youndegin; it weighed $382\frac{1}{2}$lbs., measured $22\frac{3}{4}$in. in height, $20\frac{1}{2}$in. in width, and $13\frac{1}{4}$in. in its greatest thickness. The meteorite was convex on one side, and concave on the other, while both sides were found to be pitted in a manner similar to that usually observed in

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* On a Meteoric Iron found in 1884, in the sub-district of Youndegin, Western Australia, and containing Cliftonite, a cubic form of Graphite. L. Fletcher. Min. Mag., 1887. Vol. VII., No. 34, pp. 121-130.

† On the Cliftonite and Tænite of the Meteoric Iron found in 1884, in the sub-district of Youndegin, Western Australia. L. Fletcher. Min. Mag. Vol. XII., 1899, No. 56, pp. 171-174.

other large masses of meteoric iron.* No analysis would seem to have been made of this.

Another enormous mass of meteoric iron, weighing 2044lbs., is recorded from near Youndegin, but no particulars are available.†

Roebourne.—In 1894, a meteorite was discovered by Mr. H. R. Hester on an alluvial plain 200 miles South-East of Roebourne, and eight miles from the Hamersley Range. The mass is shaped a little like the skull of an eagle; the surface being of a lustrous reddish-brown hue, with the metal showing prominently through it in some places. The mass weighed 19½lbs. The meteorite was analysed by Messrs. Mariner & Hoskins, of Chicago, Ill., and found to have the composition given in Column II. of the table appended.

Ballinoo.—Early in the year 1893, George Demmack, a shepherd, discovered a mass of meteoric iron, weighing 93lbs., on a tributary of the Murchison River, about 10 miles South of Ballinoo. In appearance the mass suggests a huge flattened potato. The original coating of the mass has entirely disappeared, except in the larger and more prominent pittings, and a few small blotches on the smooth parts, where it has a graphitic-black granulated appearance. The oxidised surface is very thin, the metal showing clearly through it on all prominent ridges. Messrs. Mariner & Hoskins, of Chicago, who analysed the sample, reported its composition to be that quoted III. in the Table.

Mooranopin.—In or before 1893 a mass of meteoric iron, weighing 2½lbs., was found by an aboriginal near Mooranopin, 160 miles East of York. Its shape is that of an oblong bar. No analysis has been made of this.‡

Analyses of Western Australian Meteoric Irons.

	1.	2.	3.
Iron	92·67	90·914	89·909
Nickel	6·46	8·330	8·850
Cobalt	0·55	0·590	0·740
Copper	Trace	*Nil*	Trace
Phosphorus	0·24	1·156	0·501
Magnesium	0·42	*Nil*	*Nil*
Manganese	*Nil*	Trace (?)	*Nil*
Sulphur	*Nil*	Trace	Trace
Silicon	*Nil*	0·010	Trace (?)
Carbon	*Nil*	Trace	Trace
Insoluble Cubes	0·04	*Nil*	*Nil*
	100·38	100·00	100·00
Sp. gr.	7·86 to 7·72	7·78	7·8

1, Youndegin; Analyst, L. Fletcher. 2, Hamersley Range; Analyst, Messrs. Mariner and Hoskins. 3, Ballinoo; Analyst, Messrs. Mariner and Hoskins.

* A Large Meteorite from Western Australia. J. R. Gregory, Nature, 1892. Vol. XLVII., pp. 90-92.

† Nature, 1892. Vol. XLVII., p. 469.

‡ Four new Australian Meteorites. H. A. Ward. Am. Journ. Sci. 1898. Vol. V. 4th series, No. 26, pp. 135–140.

The following table gives the output of iron ore within the Colony:—

The Production of Iron Ore in Western Australia.

Year.	Locality.	Ore raised.			Estimated value.			Remarks.
		tons	cwt.	qrs.	£	s.	d.	
1899 ...	Clackline	1540	5	2	...			From data supplied by the General Manager W.A. Smelting Co., Fremantle.
1899 ...	Coate's Siding ...	4712	9	3	...			
1899 ...	Greenbushes ...	2000	0	0	...			
1899 ...	Werribee	4600	0	0	...			
	Total	**12,852**	**15**	**1**	**8,939**	**11**	**3**	

CHAPTER VIII.

MISCELLANEOUS MINERALS.

Antimony, Zinc, Manganese, Mica, Cobalt, and Asbestos.

Antimony.

"There are some very good lodes of Stibnite (sulphide of antimony) in the Roebourne District, and their value in most cases is greatly increased by the quantity of gold they contain. Few of them have been worked yet, since they have mostly been mistaken for small lead lodes which were not suspected of being rich in gold." *

Zinc.

"Blende, assaying 75 per cent. of zinc, occurs in the Northampton District, and along the face of the Darling Range, associated with galena, but this ore is of no commercial value."*

* H. P. Woodward. *Loc. Cit.*

Manganese.

Manganese has been found in many places in the Colony, as can be seen by a reference to the Mineral Census, Chapter XII. Definite detailed information as to their mode of occurrence is not available. The principal sources of manganese ores are the crystalline schists and allied rocks ; some of the lodes traversing these are said to be both of large size and of excellent quality, but it still remains to be proved whether the manganese ores are of any commercial value. Black oxide of manganese is found disseminated, as an accessory mineral, throughout the ironstone deposits in the sandstones of the Kimberley District, but not in any great quantity. Certain of what have been referred to on a previous page as lateritic iron ores have yielded appreciable quantities of manganese, but so far these deposits are of no real economic importance.

Mica.

Mica is probably one of the most widely-diffused minerals in the Colony, but it is only of any real commercial value when it occurs in large sheets or can be obtained in considerable quantities. The mica-producing strata are the crystalline schists and allied rocks, which occupy fully two-thirds of the (geologically) known areas of Western Australia. Generally it is found that the mica-producing rocks are pegmatitic granites, which traverse the crystalline schists, etc., either in the form of dykes, sheets, or lenticular masses, which are often parallel to the foliation of the surrounding strata.

Under the generic term Mica several distinct mineral species are included ; they are all characterised by the readiness with which they split into very thin elastic plates. Four of the species are of commercial importance, viz., Muscovite (common or white mica) ; Phlogopite (amber mica) ; Biotite (black mica) ; and Lepidolite (lithia mica). They all occur under somewhat similar geological conditions. Two entirely different classes of mica are marketable. The first and most valuable is sheet mica, which is generally dressed into rectangular pieces of standard sizes, the smallest of which is 2 inches by $1\frac{1}{2}$ inches. The value of sheet mica increases very rapidly with its size, the largest of which may be 8 inches by 10 inches, or perhaps more. One of the most important uses of mica is for the panels of stoves and furnaces, as well as for funnels for lamps and incandescent gas lights ; for which purposes it is essential that the mica should be perfectly colourless and transparent, devoid of blemish, and should be flexible. The principal use, however, at the present time, of mica is in connection with various electrical appliances, for which the requirement is non-conductivity, implying a low iron content, and should be capable of withstanding a high temperature without disintegration. Muscovite seems to conform to these requirements more than the other varieties, and is therefore the most important mineral commercially. Lepidolite, owing to its low heat-resisting capacity, is not in great

demand, though it is used to a small extent as a source of lithium. The second marketable variety is scrap mica. The waste from the works where large mica is cut into sheets is sold as "scrap." Scrap mica is ground and used as an ingredient in lubricants for decorative purposes and as an absorbent of nitro-glycerine. An excellent non-conducting covering is formed by quilting finely-divided mica between galvanised wire netting, which forms both a flexible and fire-proof wire netting.

What may be called possible commercial mica is known to occur at the following different places in the Colony:—Nokenena Brook, Northampton; Tambourah, Pilbarra Goldfield; Mullalyup, Darling Ranges; Bindoon; The Mica Mine, Londonderry, Coolgardie Goldfield.

The following are descriptions of such of the deposits of which any definite details are available:—

Darling Ranges.—Mica has been found as far back as 1891, on Bussel's Brook, a small tributary of the Collie River. The mica occurs in granite (? pegmatite) dykes, which do not go down vertically. "These dykes run in a North and South direction. . . Near the surface, as a rule, they are much decomposed, the mica being valueless; but in one or two places hard masses outcrop where the mica is of good quality. . . ." *

Londonderry.—The mica at Londonderry is mined by means of an open cut, along the outcrop of a coarse granite dyke, which intersects the surrounding hornblendic rock. The granite, which at times assumes a pegmatitic structure, is composed of large masses (in some cases weighing as much as a hundredweight or even more) of orthoclase quartz, lepidolite, and cyanide. Muscovite is developed on a small scale, and is generally well crystallised. The only other mineral visible is chalcedony, which is found filling original holes in the rock. The most important, from an economic point of view, of the constituents of the granite is the lithia mica (lepidolite), which occurs generally in rough radiating bunches, although it occasionally appears as somewhat well-defined crystals.

The greatest size in which it (the mica) is found is 15in. by 12in., but this is exceptional, the average not exceeding 5in. to 6in. The mineral, when not less than about 1-32nd of an inch in thickness, gives a distinct sherry-red colour when examined by transmitted light, but, in sheets split finer than this, it is difficult to detect colouration. Besides these large sheets, the mica also occurs in long crystals, which, when grouped together, as they frequently are, with the longer axes parallel, present a peculiar scale-like impression. The colour of such specimens varies from a pale pink to a pale green, or is quite colourless. The cleavage of all the varieties is very perfect. †

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* H. P. Woodward. Annual General Report for the year 1890. Perth: By Authority, 1891; p. 47.

† T. Blatchford. The Geology of the Coolgardie Goldfield. Bulletin No. 3. Perth: By Authority, 1899; p. 37.

About two tons of the mica from this locality have been raised, dressed, and exported, but (probably in consequence of the low fusion point) the mineral does not seem to have found a ready sale. As a result of this, mica-mining at this locality has practically ceased.

Up to the present it does not appear that much mica of marketable value has yet been raised in the Colony. The following table gives the export of mica, as shown by the records in the Customs House:—

The Production of Mica in Western Australia.

Year.	Mica exported.	Estimated Value.	Remarks.
		£ s. d.	
1892	*	25 0 0	* Not stated.
1893	*	4 0 0	
1894	*Nil*	*Nil*	
1895	*	3 0 0	
1896	*Nil*	*Nil*	
1897	*	209 0 0	
1898	*Nil*	*Nil*	
1899	†	50 0 0	† 13 packages; weight not stated.
Total		**291 0 0**	

Cobalt.

"Cobaltiferous asbolite has been found to occur at both Norseman and Kanowna, and in both instances associated with gold. At Norseman it occurs in an auriferous quartz vein. No assays have been made of it. At Kanowna it is found abundantly in parts of the deep leads, principally in the 'pug' or bedded kaolin, and the underlying much-weathered schists; but also occurs in the nodules of magnesite and in other situations in the lead. It is almost invariably studded with minute crystals of gold. A sample of 'pug,' impregnated with asbolite, yielded in assay 7·56 per cent. of metallic cobalt." *

Asbestos.

Asbestos has been found in widely-separated localities in the Colony, but so far, with the possible exception of the mineral from Tambourah, on the West Pilbarra goldfield, most of the mineral discovered in the Colony up to the present time has proved to be actinolite, of so coarsely fibrous a nature as to be practically valueless.

The asbestos from Tambourah turns out to be fibrous chrysotile, identical with the Canadian mineral, which is so much valued. The Tambourah asbestos, unlike most of the Australian mineral,

* E. S. Simpson, Annual Progress Report of the Geological Survey for the Year 1899.

has not the great defect of a low tensile strength, and in all the points—infusibility, softness, flexibility, fineness, and the ease with which the fibres can be separated—is well above the average. No scientific examination of the district having been undertaken, no information as to the mode of occurrence of the mineral available.

The Production of Asbestos in Western Australia.

Year.	Asbestos exported.	Estimated value.	Remarks.
	Tons cwts. qrs.	£ s. d.	
1899 ...	*	1 0 0	* One package; weight not stated.

CHAPTER IX.

COAL AND GRAPHITE.

COAL.—GÉNERAL—IRWIN RIVER COALFIELD, COLLIE COALFIELD, THE VASSE, FLY BROOK, KIMBERLEY, BROWN COALS OF THE SOUTH COAST.

GRAPHITE.—CHAMPION BAY, KENDENUP, DONNELLY RIVER.

So far as observations have at present been carried, the coalfields of the Colony fall into three main divisions, viz., the carboniferous rocks of the Irwin, the mesozoic beds of the Collie, the Vasse, and Fly Brook, and the brown coals of the South Coast. It is, however, from the mesozoic rocks that the bulk of the coal of Western Australia has, up to the present, been derived, though considering the great extension of the undoubted carboniferous beds to the North of the Irwin—which cannot be said to have been either prospected or systematically examined—it is by no means unlikely that valuable seams occur.

The coalfields are described in the order of their geological age, and without reference to their geographical position. This method, though not without its disadvantages, is perhaps the most satisfactory in the present condition of our knowledge.

THE IRWIN COALFIELD.

This coalfield was examined and reported upon by H. P. Woodward in 1895.* The following particulars with reference thereto are culled from his report, whilst the geological map shows the area over which the coal measures occupy the surface :—

"The Irwin Coalfield is situated upon what is generally known as the Upper Irwin, or, in other words, the area drained by the various Eastern branches of the Irwin River. The tract of country lies between 30 and 40 miles from the coast, and is extremely fertile. . . . The carboniferous basin spreads out to the Eastward, covering a fan-shaped area, which is surrounded on most sides by cliffs of horizontally-bedded sandstone, about 200 feet in height, which form the edge of the sandy tableland, and it is at the base of these beds where they rest directly, but generally unconformably upon the shales, that springs break out at several places, which form the principal water supply of the district. . . . Indications of coal were first reported to exist upon the Irwin River by Gregory, in the year 1846, which report was a little later confirmed by the Geologist (Dr. Von Sommer), who stated that there were two seams, six feet and eight feet respectively, and it was upon this report that the Government declared a reserve of 10,000 acres. For over 30 years this important discovery was not investigated further, but in the year 1879 the Legislative Council voted the sum of £100 in order to test the quality of the coal, with which object a shaft was sunk to a depth of 50 feet, in which, although no coal was struck, the indications were considered promising. A little later the Government sent the Rev. C. G. Nicolay, M.A., who reported that on account of the great quantity of water met with in sinking and the poor quality of the coal, the discovery was of no value. The field was therefore abandoned until the year 1888, when Messrs. Bell and Elliot found some fragments of coal in the bed of the North Branch, which proved to be of a very fair quality. These they traced up to their source, which they found to be a seam of about four feet in thickness, into which they put a drive 150 feet down the dip, but although it improved both in size and quality, it did not prove at the time to be of sufficient value to induce them to expend any more money upon its development.

"Another lower seam of smutty coal, about two feet in thickness, was also opened up, and about 10 tons raised, which proved to be of a rather better quality, but work was then discontinued. . . Some more seams were also opened up upon another branch, but they did not prove at the time of any value, on account of there being no local demand for coal, and also because the quality was not good enough for export.

"The carboniferous area spreads out from Mingenew in an Easterly direction, covering an area of about 200 square miles, its greatest length from North to South, from Badgeree Pool, upon

* On the Carboniferous Areas in the Irwin River Basin. Appendix 1: Report of the Department of Mines for the year 1895, pp. 19-21. Perth; By Authority: 1896.

the North Branch, to Mt. Scratch, being about 30 miles, while its greatest width, from Mingenew to Marandagry, upon the Lockier River, is about 17 miles. To the North-West this area is bounded by the high sandy tableland which extends away to the Northward as far as the Greenough River. The South is bounded for the most part by the low outcrops of metamorphic rock, which contain many copper lodes; to the Eastward by the bold escarpment of crystalline rocks, flanked by horizontally-bedded Tertiary sandstones, which often present towards the plains vertical cliff faces of as much as 200 feet, particularly where streams have cut deep channels through them; whilst to the Westward it is bounded by more high sandy plains which extend as far as the coast. Of these boundaries that to the South and East may be taken as the definite edges of the carboniferous formation, but that to the North and West only as provisional, since the sandstones which form the high sand plain in these directions are of a much more recent date, and may overlie extensions of the carboniferous formation, and since it is known that carboniferous rocks occur in the river valleys further to the Northward it is highly probable that they are part of the same formation; and if this should prove to be the case valuable coal deposits may be found beneath the high sand plains which lie between the Irwin, Greenough, and Murchison Rivers."

The Coal Measures consist of a series of shales, sandstones, and limestones, which are very rich in marine fossils.

So far as researches have at present been carried, no estimate of the thickness of these beds has been found possible.

The coal seams are said to occur in these beds intimately associated with carbonaceous shales. The coal is dirty to the touch, and, owing to the relatively high percentage of water, it rapidly decrepitates on exposure to the atmosphere.

The following table shows the analyses of the Irwin River coals:—

Chemical Analyses of Coals from the Irwin River Basin.

No. of Analysis.	Description of Sample.	Analyst.	Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.
1	Irwin Coal Seam	Mr. Harland (London)	17·04	28·61	41·29	13·06	
2	Do.	Mr. Wingham (London)	12·4	32·2	43·5	11·9	0·83
3	Do.	B. H. Woodward ...	15·63	23·06	39·32	21·99	
4	Do. Top ...	Assayer Wanerauooka Mine Northampton	26·50	16·00	57·50		0·15
5	Do. Middle	do.	23·00	18·00	59·00		0·10
6	Do. Bottom	do.	23·00	18·00	59·00		0·10
	Mean of Six Samples		**19·59**	**22·64**	**57·76**		**0·19**

A series of bores were put down by the Midland Railway Company, but no record appears to have been kept of the strata pierced. The deepest bore is said to have attained a depth of about 500 feet, but, as the work was stopped in black shale, before the base of the beds had been reached, very little useful information resulted.

Having in view the delimitation of the Westward boundary of the Irwin River Coal Measures, a bore was put down by the Government at Dongara. The bore attained a depth of 2,111 feet 7 inches, when operations were stopped owing to the capabilities of the boring plant being exhausted, without having proved the presence of the Irwin River beds.

The following is a section of the strata pierced as compiled from the bore journals supplied by the Department of Public Works:—

Dongara Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Formation.
Sand	6	0	...		Coastal Limestone
Clay	3	6	6	0	Do.
Sandstone	50	6	9	6	Do.
Limestone	12	0	60	0	Do.
Sandstone	23	0	72	0	Do.
Clay	45	0	95	0	Do.
Micaceous Sandstone ...	90	0	140	0	Mesozoic
Drift Sand (Incoherent Sandstone ?)	30	0	230	0	Do.
Sandstone with Coal Seams	45	0	260	0	Do.
Carbonaceous Shale ...	4	0	305	0	Do.
Sandstone	110	0	309	0	Do.
Sandstone with veins of Coal	15	4	419	0	Do.
Sandstone	42	8½	434	4	Do.
Sandstone with bands of Carbonaceous Shale	12	9	477	0½	Do.
Sandstone	42	11	489	9½	Do.
Grey Shale...	2	0	532	8½	Do.
Sandstone	705	11½	534	8½	Do.
Shale...	9	11	1,240	8	Do.
Sandstone with thin Shale band	124	10	1,250	7	Do.
Micaceous Shale	28	7	1,375	5	Do.
Sandstone	88	6	1,404	0	Do.
Shale...	57	3	1,492	6	Do.
Sandstone	100	0	1,549	9	Do.
Micaceous Shale	82	7	1,649	9	Do.
Sandstone	379	3	1,732	4	Do.
Total	2,111	7	2,111	7	

At a depth of 149 feet, water was met with in a bed of sandstone, and stood at 17 feet from the surface. On further boring to a depth of 935 feet the water rose within 2 feet 6 inches of the

surface. When operations had reached 1,023 feet in a coarse, grey sandstone, the water rose to the surface. The first overflowing supply was encountered in a micaceous sandstone at a depth of 1,259 feet 7 inches, the yield being 128 gallons per hour; this flow increased to 240 gallons per hour at a depth of 1,327 feet, the water being obtained from a bed of micaceous sandstone. Fresh water, flowing at the rate of 3,600 gallons per hour, was met with at 1,384 feet. The water, which is said to have flowed from a micaceous shale, issued with a temperature of 98 degrees, and rose 22 feet above the surface.

An analysis of a 4-inch seam occurring at 265 feet, carried out in the official laboratory, showed its composition to be in parts per hundred :—

Moisture	13·13
Volatile Hydro-carbon	29·47
Fixed Carbon	49·40
Ash...	8·00

THE COLLIE COALFIELD.

The Collie Coalfield is situated about 25 miles due East of Bunbury, upon the Collie River, at an altitude of about 600 feet above sea level. The Collie River rises in that elevated tableland between the head of the Murray and the Blackwood, and, after flowing generally North-West, enters the sea at Leschenault Inlet, to the North of the town of Bunbury. The existence of a coalfield has been known since somewhere about the year 1890, although coal would seem to have been discovered some six years before.

The Collie field covers an area of about 12 miles in length, in a North-West and South-East direction, with a width of about four miles; it embraces an area of about 50 square miles. The field is traversed through its whole length by the North and South branches of the Collie River, and is connected by rail with the main railway system of the Colony.

The Coal Measures consist of a series of sandstones conglomerates, shales, and coal seams, but, owing to the peculiarities of the basin, the measures are however seldom visible at the surface, being covered by a more recent deposit derived from the weathering, *in situ*, of the beds beneath. This recent deposit is often cemented together by oxide of iron, forming what is locally designated as ferruginous conglomerate. The Coal Measures readily decompose into a sandy soil, which contributes in no small measure to the concealment of the underlying rocks.

Any visible outcrops of the Coal Measures are found only along lines of most rapid erosion, and that is along the water-courses. At several places in the bed of the Collie River, just below the water-level, in the vicinity of Coal Mining Lease 110, are apparently horizontally bedded sandstones belonging to the Coal Measures.

The Coal Measures have been deposited in a comparatively unsymmetrical shallow basin of erosion. Cases occur in which a portion of the seams has been eroded, and the channel so formed filled with deposits of sand. The strata do not appear to have been subjected to any serious disturbance, and to have suffered little or no lateral pressure. So far as mining operations have at present been carried, the beds all dip at a comparatively low angle into the basin. This low dip may, in part, be due to the changes produced by the consolidation and the settling of the strata in the basin in which the vegetable and other matter was deposited. During this process, the more unyielding material beneath the coal would have a tendency to produce those "rolls" so common in some parts of the field. The effects of this settling are shown by the small faults, in reality cracks, which have been discovered in the course of the workings along the edge of the coal basin.

Mining operations have, so far, shown that workable seams appear to be confined to the series of sandstones and shales that constitute the sixty or seventy feet below the level of the bed worked in the Government mine, now better known as the Wallsend Colliery. These seams are within comparatively easy reach of the surface along the Northern periphery of the basin, as has been proved by the records of the hand bores put down at the instance of the Government, under the direction of Mr. W. B. Pendleton. In all, 18 bores were put down. The following tables show the results obtained :—

Record of Strata pierced by Pendleton's Hand Boring Plant.

No. of Bore.	Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
1	Measures ..	37	0	...	
	Coal ...	0	9	37	0
	Measures ...	12	10	37	2
	Total ...	50	0	50	0
2	Measures ...	2	9	...	
	Coal ...	3	10	2	9
	Measures ...	13	5	6	7
	Total ...	20	0	20	0
3	No data; running sand.				
4	Measures ...	40	0	...	
	Coal ...	17	11	40	0
	Measures ...	6	1	57	11
	Coal ...	1	7	64	0
	Measures ...	54	5	65	7
	Coal ...	0	3	120	0
	Measures ...	3	9	120	3
	Coal ...	4	0	124	0
	Measures ...	2	0	128	0
	Coal	2	9	130	0
	Measures ...	19	3	132	9
	Coal ...	4	0	152	0
	Measures ...	11	0	156	0
	Coal ...	2	0	167	0
	Measures ...	3	0	169	0
	Coal ...	3	6	172	0
	Measures ...	2	6	175	6
	Coal ...	0	2	178	0
	Measures ...	20	0	180	0
	Total ...	200	0	200	0

Record of Strata pierced by Pendleton's Hand Boring Plant—continued.

No. of Bore.	Nature of Strata.	Thickness. ft.	Thickness. in.	Depth. ft.	Depth. in.
5	Measures ...	10	0	10	0
	Coal ...	11	3	10	0
	Total ...	21	3	21	3
6	Measures ...	42	0	...	
	Coal ...	1	0	42	0
	Measures ...	19	0	43	0
	Coal ...	7	0	62	0
	Measures ...	22	0	69	0
	Coal ...	2	0	91	0
	Measures ...	9	0	93	0
	Coal ...	1	0	102	0
	Measures ...	24	0	103	0
	Coal ...	7	6	127	0
	Measures ...	1	6	134	6
	Total ...	136	0	136	0
7	Measures ...	184	0	184	0
	Total ...	184	0	184	0
8	Measures ...	123	0	...	
	Coal ...	11	0	123	0
	Measures ...	16	0	134	0
	Total ...	150	0	150	0
9	Measures ...	58	0	...	
	Coal ...	0	11	58	0
	Measures ...	51	1	58	11
	Coal ...	8	4	110	0
	Measures ...	75	8	118	4
	Total ...	194	0	194	0
10	Measures ...	77	0	...	
	Coal ...	1	0	77	0
	Measures ...	8	0	78	0
	Coal ...	2	0	80	0
	Measures ...	165	0	82	0
	Total ...	245	0	245	0
11	Measures ...	17	0	...	
	Coal ...	12	0	17	0
	Measures ...	1	0	29	0
	Total ...	30	0	30	0
12	Measures ...	18	0	...	
	Coal ...	22	2	18	0
	Measures ...	0	10	40	2
	Total ...	41	0	41	0
13	Measures ...	15	0	...	
	Coal ...	6	10	15	0
	Measures ...	4	2	21	10
	Coal ...	9	6	26	0
	Measures ...	27	6	35	6
	Total ...	63	0	63	0
14	Measures ...	40	0	...	
	Total ...	40	0	40	0
15	Measures ...	44	0	...	
	Coal ...	0	7	44	0
	Measures ...	13	5	44	7
	Coal ...	6	0	58	0
	Measures ...	16	0	64	0
	Coal ...	1	4	80	0
	Measures ...	2	8	81	4
	Total ...	84	0	84	0
16	Measures ...	53	0	...	
	Coal ...	1	2½	53	0
	Measures ...	37	9½	54	2½
	Coal ...	10	1	92	0
	Measures ...	12	11	102	1
	Coal ...	0	7½	115	0
	Measures ...	51	4½	115	7½
	Coal ...	4	3	167	0
	Measures ...	1	9	171	3
	Coal ...	4	8	173	0
	Measures ...	15	4	177	8
	Coal ...	2	10	193	0
	Measures ...	28	2	195	10
	Coal ...	5	0	224	0
	Measures ...	1	0	229	0
	Coal ...	9	9½	230	0
	Measures ...	10	2½	239	9½
	Total ...	250	0	250	0

Record of Strata pierced by Pendleton's Hand Boring Plant—continued.

No. of Bore.	Nature of Strata.	Thickness.		Depth.	
		ft.	in.	ft.	in.
17	Measures ...	35	0	...	
	Coal ...	0	3	35	0
	Measures ...	9	9	35	3
	Coal ...	0	1	45	0
	Measures ...	55	5	46	0
	Total ...	101	0	101	0
18	Measures ...	47	0	...	
	Coal ...	1	1	47	0
	Measures ...	16	11	48	1
	Coal ...	3	4	65	0
	Measures ...	16	8	68	4
	Coal ...	1	6	85	0
	Measures ...	12	6	87	6
	Total ...	100	0	100	0

The coal seams vary in thickness from that of a sheet of paper up to about 13 feet. The coals are hydrous, non-caking, and bituminous; they approach very closely to lignites in some parts. Between the two varieties the differences are only of degree, for there are really no distinctive characters which would find universal application. Owing to the conditions of deposition the coals naturally vary in character, and in places pass insensibly through forms containing a large proportion of earthy matter to carbonaceous shales.

The analyses in the table appended may, with the exception of No. 21 (which is, in reality, a very carbonaceous shale), be regarded as representative of the commercial coals of the field. The water contents of the coal vary from 7 to a little over 15 per cent. The average percentage of volatile hydro-carbons is about 30, but shows a variation from 21 to 35 per cent. The fixed carbon fluctuates between 27 to 56 per cent., but has an average of about 49·08. The ash of the coal does not, so far, appear to possess any peculiarities; the analyses show that it ranges between 1 and 33 per cent., but amounts in the average to about 8·62 parts per hundred.

Chemical Analyses of Coals from the Collie River Basin.

No. of Analysis.	Description of Sample.	Analyst.	Specific Gravity.	Calorific Value. Pounds evaporated.	Calorific Value. British Thermal Units.	Percentage Composition. Moisture.	Percentage Composition. Volatile Hydro-carbons.	Percentage Composition. Fixed Carbon.	Percentage Composition. Ash.	Percentage Composition. Sulphur.
1	Pendleton's Shaft near T. 26	B. H. Woodward, February, 1893	...	7·70	7·440	7·94	29·70	55·75	6·61	*Nil*
2	Do. do.	Do. April, 1893 ...	...	7·70	7·440	13·30	22·08	56·36	8·26	*Nil*
3	Near T. 26, a few feet deep	Royal School of Mines, March, 1890	...	...	...	12·75	37·04	46·70	2·80	0·71
4	First sample from River bed	B. H. Woodward, November, 1889	...	...	...	15·20	32·46	45·03	5·08	2·23
5	Same seam, 17ft. deep	Do. April, 1890 ...	...	...	...	10·87	31·47	52·87	2·56	2·23
6	Do. top	Do. October, 1891 ...	...	6·06	5·910	13·65	34·88	48·35	3·12	1·09
7	Do. bottom	Do. do. ...	...	6·06	5·910	13·85	35·90	45·93	4·32	1·18
8	Outcrop at T. 17	Do. April, 1890 ...	...	...	...	11·70	21·83	54·17	9·31	2·99
9	Diamond Drill Bore No. 2, 2ft. 7in. seam, 61ft. from surface ...	Do. January, 1895 ...	...	...	...	11·00	33·98	52·83	2·19	
10	Do. do. 8ft. 3in. seam, 133ft. from surface ...	Do. do. ...	...	...	...	11·27	32·76	53·51	2·46	
11	Government Mine, 100ft. deep; not air-dried	Do. May, 1895 ...	...	7·26	7·080	14·59	34·69	49·07	1·74	Trace
12	Do. do. air-dried	Do. do. ...	1·291	6·03	5·290	11·40	35·94	50·85	1·81	0·53
13	Seam 5 miles West at T. 17; not air-dried	Do. do. ...	...	...	...	13·00	35·15	48·54	3·31	Trace
14	Do. do. air-dried	Do. do. ...	1·308	...	...	7·00	35·57	51·89	3·54	
15	Hay's 3ft. seam	Do. February, 1895	...	...	...	9·37	33·46	50·94	6·23	Trace
16	Government Mine, 16ft. seam, 100ft. from surface	D. A. Sutherland, August, 1895 ...	1·408	10·12	9·780	11·75	24·74	56·43	6·85	0·23
17	Do. do. do.	Johnson & Sons, do. ...	1·287	...	...	11·50	23·74	56·98	7·42	0·36
18	G.S.M. 247, West Collie Proprietary; air-dried for six months	E. S. Simpson, November, 1897 ...	1·211	12·10	11·700	10·93	32·86	52·87	3·34	0·59
19	G.S.L. 535	Do. April, 1898 ...	1·356	10·40	10·050	13·95	27·89	52·25	5·91	0·44
20	G.S.M. 718, West Collie Proprietary; Top Coal	Do. July, 1898 ...	1·327	11·55	11·120	12·07	31·75	48·10	8·08	2·00
21	G.S.M. 719, do. band below Top Coal ...	Do. do. ...	1·565	7·15	6·910	9·10	27·18	33·85	29·87	0·10
22	G.S.M. 720, do. Bottom Coal	Do. do. ...	1·417	10·45	10·090	10·60	26·00	46·85	16·55	0·39
23	G.S.M. 721, Collie Proprietary	Do. do. ...	1·409	10·12	9·730	13·98	25·82	53·51	6·69	0·05
24	G.S.M. 722, heap at surface, Government Mine	Do. do. ...	1·419	11·15	10·740	12·03	25·65	54·78	7·54	0·10
25	G.S.L. 715, West Collie Proprietary, A1	Do. August, 1898 ...	1·267	11·82	11·430	14·57	36·61	44·80	4·02	
26	G.S.L. 710 do. A	Do. do. ...	1·319	11·16	10·790	13·87	32·62	45·63	7·88	
27	G.S.L. 711 do. B	Do. do. ...	1·356	10·61	10·270	11·22	29·58	44·89	14·31	
28	G.S.L. 712 do. C	Do. do. ...	1·436	10·50	10·150	10·73	28·35	45·05	15·87	
29	G.S.L. 713 do. D	Do. do. ...	1·448	9·73	9·410	10·98	25·58	45·33	18·11	
30	G.S.L. 714 do. E	Do. do. ...	1·468	9·52	9·200	10·33	25·48	45·63	18·56	
31	G.S.L. 716 do. E2	Do. do. ...	1·525	9·90	9·570	8·94	29·61	27·57	33·88	0·37
32	West Collie Proprietary; average used on Locomotive trials, January, 1898	E. A. Mann, January, 1898 ...	..	11·69	11·300	7·63	34·94	45·84	11·59	0·90
33	G.S.M. 1090, Wallsend Colliery (late Government Mine) ...	E. S. Simpson, February, 1899 ..	1·368	9·95	9·610	15·05	24·95	53·30	6·70	0·23
34	G.S.M. 1091, do. do.	Do. do. ...	1·408	10·18	9·830	14·17	26·63	52·43	6·77	0·19
	Mean of thirty-four samples		**1·379**	**9·53**	**9·200**	**11·77**	**30·20**	**49·08**	**8·62**	**0·84**

The seam upon which operations have so far chiefly been centred is that outcropping in the bed of the river on the Southern boundary of Coal Mining Lease 85, near T. 26; it is worked by a tunnel driven along the seam, in a general Southerly direction, for a distance of about 1,407 links. The dip of the seam is about eight degrees to the Southward. An air shaft has been put down some distance from the mouth of the tunnel, and intersected the seam at a depth of 41 feet from the surface. The shaft was carried down a further distance of 74 feet.

The section in the shaft is as follows:—

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures *	23	6	...	
Coal	0	2	23	6
Measures	0	9	23	8
Coal	2	10	24	5
Measures	1	3	27	3
Coal	12	6	28	6
Measures	6	4	41	0
Coal	2	6	47	4
Measures	66	1	49	10
Total	115	11	115	11

It is estimated that had this shaft been continued a further distance of about 8 feet, the 4-feet seam reported at 124 feet, No. 4 Hand Bore (*Vide supra*), would have been met with.

Number 4 Diamond Drill Bore, which has been put down about 50 chains South-West from the Government Mine, intersects that seam at a depth of 616 feet. The section which has been compiled from the bore journals gives a complete section for about 600 feet above the level of the Government mine seam, and about 300 feet below it. The record also shows a 4-feet seam of coal lying about 46 feet beneath the Government mine seam, and also another of equal thickness of about 100 feet lower down.

The uppermost 4-feet seam may be correlated with the 4-feet seam which the section in No. 4 hand bore shows to exist about 80 feet below the mine seam. It is noteworthy that No. 9 Hand Bore was met with in No. 4 Diamond Drill Bore which is situated some little distance to the West.

* Full details as to the nature of the measures in this and subsequent tables will be found on pp. 13-21 of the Annual Progress Report of the Geological Survey for the Year 1898. Perth; By Authority: 1899.

No. 4.—*Diamond Drill Bore.*

580 feet above Sea Level.

Nature of Strata.	Thickness. ft. in.	Depth. ft. in.	Remarks.
Measures	406 5	...	Artesian water commenced to flow at 80 feet in depth from a bed of grey sandstone in this bore; as the work was continued, the supply gradually increased until the grey sandstone was reached at a depth of 634 feet, when it was flowing at the rate of 15,000 gallons per diem; and, when boring operations ceased, water was flowing at the rate of 25,000 gallons per day.
Coal	0 9	406 5	
Measures	87 8	407 2	
Coal	0 6	494 10	
Measures	92 9	495 4	
Coal	11 0	588 1	
Measures	10 8	599 1	
Coal	3 0	609 9	
Measures	3 6	612 9	
Coal	13 4	616 3	
Measures	32 10	629 7	
Coal	4 0	662 5	
Measures	96 7	666 5	
Coal	4 0	763 0	
Measures	22 1	767 0	
Coal	2 8	789 1	
Measures	109 1	791 9	
Total ...	900 10	900 10	

Between the outcrop of the Government Mine seam and the granitic rocks to the North, two shafts have been put down by a South Australian syndicate, with the object of testing the measures below the seam. No record would, however, seem to have been kept of the strata pierced by the shafts.

Shaft No. 1, on Coal Mining Lease 85, so far as can be judged by the material lying at grass, appeared to pass through white, gritty sand (fine conglomerate ?), associated with the Coal Measures. The most Northerly shaft, No. 2, entered, after penetrating the superficial cover of ferruginous conglomerate, the crystalline rocks which form the floor of the basin.

Diamond Drill Bore No. 2, on the North bank of the Collie River, on Coal Mining Lease 100, of which the section exposed is appended, pierced an 8-feet seam of coal at a depth of 127 feet from the surface.

No. 2—*Diamond Drill Bore.*

587 feet above Sea Level.

Nature of Strata.	Thickness. ft. in.	Depth. ft. in.	Remarks.
Measures	55 1	...	A fine stream of artesian water, yielding about 50,000 gallons per diem, flows from this bore.
Coal	2 7	55 1	
Measures	69 7	57 8	
Coal	8 3	127 3	
Measures	103 5½	135 6	
Coal	0 2	238 11½	
Measures	6 8	239 1½	
Coal	0 10	245 9½	

No. 2—*Diamond Drill Bore*—continued.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Measures	62	10	246	7½	
Coal	0	8	309	5½	
Measures	4	7½	310	1½	
Coal	0	4	314	9	
Measures	1	7	315	1	
Coal	0	2	316	8	
Measures	3	8	316	10	
Coal	0	4½	320	6	
Measures	4	6½	320	10½	
Coal	0	6½	325	5	
Measures	42	3½	325	11½	
Coal	0	8	368	3	
Measures	64	1	368	11	
Coal	0	9	433	0	
Measures	296	9	433	9	
Coal	1	0	730	6	
Measures	45	0	731	6	
Coal	1	0	776	6	
Measures	172	9	777	6	
Coal	1	3	950	3	
Measures	0	4	951	6	
Total ...	951	10	951	10	

Some little distance to the West of the Wallsend Colliery, a private diamond drill has been used to test the measures to a depth of 500 feet. The bore is situated near the South-Eastern corner of Coal Mining Lease 105. The following is a record of the strata pierced :—

Calyx Drill Bore, West Collie Coal Proprietary Company, Coal Mining Lease 105.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	157	0	...	
Coal	2	0	157	0
Measures	40	8	159	0
Coal	0	6	199	8
Measures	20	4	200	2
Coal	0	3	220	6
Measures	20	9	220	9
Coal	0	2	241	6
Measures	37	4	241	8
Coal	3	0	279	0
Measures	69	7	282	0
Coal	2	0	351	7
Measures	18	1	353	7
Coal	2	8	371	8
Measures	12	7	374	4
Coal	6	0	386	11
Measures	110	6	392	11
Total	503	5	503	5

There appears to be no coal at all comparable with that in the Wallsend Colliery in this section, unless the seams have thinned out considerably in this direction, or a fault passes between the two localities.

The strata at the Western end of the field, where the discovery of coal was first made, have been tested by means of shafts and bore holes. Number 7 Diamond Drill Bore near the Northern edge of the basin, as can be seen by the section, attained a depth of 528 feet, and passed through but one seam of coal nine inches thick.

No. 7.—*Diamond Drill Bore.*

Altitude, 591 feet above Sea Level.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	268	0	...	
Coal	0	9	268	0
Measures	259	3	268	9
Total	528	0	528	0

Further to the West, No. 6 Diamond Drill Bore penetrated to a depth of 424 feet below the surface, and passed through six seams of coal, the largest being returned as 5 feet 6 inches in thickness.

No. 6.—*Diamond Drill Bore.*

Altitude, 580 feet above Sea Level.

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	38	1	...	
Coal	1	5	38	1
Measures	22	4	39	6
Coal	0	6	61	10
Measures	17	2	62	4
Coal	5	6	79	6
Measures	107	6	85	0
Coal	0	6	192	6
Measures	9	6	193	0
Coal	1	0	202	6
Measures	6	6	203	6
Coal	1	6	210	0
Measures	212	6	211	6
Total	424	0	424	0

A short distance due South of this Bore, a vertical shaft has been put down to a depth of 135 feet, of which the following particulars have been supplied :—

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	25	0	..	
Coal	0	7	25	0
Measures	31	3	25	7
Coal	0	3	56	10
Measures	1	1	57	1
Coal	0	10	58	2
Measures	28	4	59	0
Coal with Carbonaceous Shale bands	2	6	87	4
Measures	12	3	90	10
Data incomplete	...		...	

Between the roof and the floor of the seam worked is said to be 14 feet. Seventeen feet above this seam is another, showing 18 inches of coal, and 18 inches of shale.

On Coal Mining Leases 86 and 89 a good deal of exploring has been done. A seam of coal has been worked from the outcrop by an inclined shaft. The section of the seam (Collie Proprietary) is as follows :—

	Feet.	Inches.	
Coal	4	6	Top seam.
Shale	1	4	
Coal	0	2	
Clay Band	0	2	
Sandstone	4	9	
Carbonaceous Shale	2	0	
Coal	2	3	Bottom Seam.
Carbonaceous Shale	0	6	
Coal	2	6	

Two hand bores have been put down to the Eastward of the inclined shaft, and pierced the seams at 30 and 43 feet respectively.

The strata passed through are as follows:—

Bore on Coal Mining Lease No. 89, 86 yards East from the mouth of the Day-hole.

Nature of Strata.		Thickness.		Depth.	
		ft.	in.	ft.	in.
Measures		30	0	...	
Coal	Top Seam ...	6	0	30	0
Black Shale	Top Seam ...	1	0	36	0
Coal	Top Seam ...	1	0	37	0
Measures		6	0	38	0
Coal ..	Bottom Seam ...	8	0	44	0
Measures		14	0	52	0
Total		66	0	66	0

The following is a section of the strata pierced in the hand bore on Coal Mining Lease 89, distant 89 yards to the South-East of the tunnel above mentioned:—

Bore on Coal Mining Lease 89.

Nature of Strata.		Thickness.		Depth.	
		ft.	in.	ft.	in.
Measures		14	0	...	
Coal (smut)		2	0	14	0
Measures		27	2	16	0
Coal	Top Seam	4	6	43	2
Black Shale bands	Top Seam	0	6	47	8
Coal		1	4	48	
Measures		5	11	49	
Coal	Bottom Seam	2	3	55	
Shale	Bottom Seam	0	6	57	
Coal	Bottom Seam	2	9	58	
Measures		1	0	60	11
Total		61	11	61	11

The coal met with in Government Hand Bores 13 and 14 to the North of the main workings are probably on a lower horizon than the Collie Proprietary seam. No. 13 Hand Bore penetrated two seams, the first about seven feet thick at a depth of 15 feet, and the 9 feet 6 inches seam at a vertical depth of 26 feet below the surface. About 15 chains East of this is No. 14 bore, which was carried down 84 feet 2 inches, when a seam of coal was met with; its thickness was never tested, owing to the abandonment of the bore. The seams in No. 3 Hand Bore may probably be those shown in No. 4 Diamond Drill Bore at 609 and 616 feet respectively; these being the only coals at all comparable with them.

The centre of the coal basin has been explored by means of Diamond Drill Bore No. 3, down to a depth of 270 feet, and

several seams of coal met with. The section of this bore is as follows:—

No. 3.—*Diamond Drill Bore.*

592 feet above Sea Level.

Nature of Strata.	Thickness. ft.	Thickness. in.	Depth. ft.	Depth. in.
Measures	35	0	...	
Coal	2	8½	35	0
Measures	66	6	37	8½
Coal	0	3	106	2½
Measures	40	6	106	5½
Coal	1	5	146	11½
Measures	10	7½	148	4½
Coal	5	0	159	0
Measures	13	9½	164	0
Coal	2	3½	177	9½
Measures	44	2	180	1
Coal	0	7	224	3
Measures	11	5½	224	10
Coal	0	6	236	3½
Measures	33	6	236	9½
Total	270	3½	270	3½

The Northern outcrop of the field, just to the North of Coal Mining Lease 171, was explored by No. 1 Diamond Drill Bore, and the granite beneath the sedimentary beds met with at a depth of 417 feet. No coals were met with. The strata are obviously on a lower horizon than those with which the coals are associated at Wallsend.

Diamond Drill Bore No. 5 was sunk to a depth of 96 feet, some little distance outside the Western edge of the Coal Measures. The bore passed through 91 feet of superficial deposits, and penetrated 5 feet into an olivine diorite, when operations ceased.

The Collie Coalfield being situated in a comparatively small basin at some considerable elevation above the Coastal Plain, it is by no means improbable that similar areas exist along the coast, where the physical conditions are favourable to the deposition of coal seams. That such a condition is highly probable is shown by the fact that in places along the range fragments of strata identical with those on the Collie are seen resting directly upon the underlying rocks. It is reported that many years ago, what was reputed to be a seam of coal was met with in one of the branches of the Preston, eight miles from Bunbury, at a place called the "Coal Pits." Two bores were put down, and in one of them 12 inches of good coal were obtained; no record would, however, seem to have been kept of the strata pierced in these bores.

With the object of testing the country beneath the Coastal Plain in this district, a Calyx Drill Bore was put down to a depth of 1016 feet * on the Dardanup Estate. The strata pierced consisted

* 24th January, 1900.

chiefly of sands, clays, sandstones, and shales. A seam of bituminous coal was met with at 150 feet from the surface, the bed being 6 inches in thickness; at 452 feet another seam of 5 inches was pierced. The bore is still in progress.

An analysis of the coal from Dardanup was made in the official laboratory, with the following result:—

Moisture	14·36
Volatile Hydro-carbons	35·89
Fixed Carbon	64·14
Ash	3·61
	118·00

It is not known from which of the two seams the sample was obtained.

THE VASSE.

A good deal of experimental boring has been carried out since the year 1892 in the neighbourhood of the Vasse River, which enters Geographe Bay near Wonnerup, some miles to the North of Cape Naturaliste.

In all there have been six recorded bores, in the whole of which 25 coal seams have been reported. The greatest thickness of coal in any one bore was about 3 feet 6 inches. No analyses of the most promising of the beds appear to have been made. In two bores only does the floor of crystalline rocks, upon which the strata were laid down, appear to have been met with.

So far as may be judged from the bore journals, the strata consist largely of sand—in all probability an incoherent sandstone—shales, with pyritous nodules, and dark and yellow clays. They in all probability represent the Northward continuation of the Fly Brook beds.

The following tables give such particulars with reference to the coals passed through as are available:—

No. 1.—*Section of Bore six miles from Busselton on the Vasse River.*

Nature of Strata.	Thickness.	Depth.
	ft. in.	ft. in.
Measures	19 0	...
Coal	3 0	19 0
Measures	137 0	22 0
Total	159 0	159 0

The seam of coal in this bore is said to be the same as that met with at 93 feet 6 inches in Bore No. 3. This bore also penetrated mixtures of coal and clay at different depths.

No. 2.—*Section of Bore five miles from Busselton, at the Vasse.*

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	88	7	...	
Coal	3	0	88	7
Measures	52	0	91	7
Total	143	7	143	7

No. 3.—*Section of Bore four miles from Busselton, on Fairlawn Estate.*

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	93	9	...	
Coal	1	1*	93	9
Measures	31	8	94	10
Coal	0	7	126	6
Measures	19	1	127	1
Coal	1	2	146	2
Measures	27	10	147	4
Coal	3	5½	175	2
Measures	69	4½	178	7½
Coal	...		248	0
Measures	21	2	...	
Total	269	2	269	2

No. 4.—*Section of Bore five miles from Busselton.*

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Measures	96	0	...	
Coal	2	0	96	0
Measures	18	0	98	0
Coal	4	0	116	0
Measures	62	0	120	0
Coal	1	0	182	0
Measures	57	0	183	0
Coal	1	0	240	0
Measures	6	0	241	0
Coal	1	6	247	0
Measures	21	0	248	6
Coal	1	6	269	6
Measures	161	0	271	0
Coal	2	0	432	0
Measures	12	2	434	0
Total	476	2	476	2

* This seam of coal is said to be the equivalent of that met with at 19 feet in Bore No. 1.

No. 5.—*Section of Bore six miles from Busselton, on the Vasse River.*

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
Measures	53	11	...	
Coal	0	1	53	11
Measures	157	0	54	0
Coal	0	1	211	0
Measures	162	11	211	1
Coal	1	6	374	0
Measures	97	6	375	6
Coal	1	0	463	0
Measures	191	6	464	0
Granite and Gneiss	1	0	655	6
Total	656	6	656	6

No. 6.—*Section of Bore at Newton, near Busselton.*

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.
Measures	113	0	...	
Coal (inferior)	1	6	113	0
Measures	21	0	114	6
Dark Shale with two four-inch coal bands	2	0	135	6
Measures	69	6	137	6
Coal (inferior)	1	6	207	0
Measures	4	0	208	6
Coal	0	6	212	6
Measures	21	6	213	0
Coal	1	0	234	6
Measures	9	0	235	6
Coal	0	6	244	6
Measures	33	6	245	0
Coal	0	6	278	6
Measures	2	0	279	0
Coal	0	3	281	0
Measures	49	0	280	9
Gneiss	0	3	329	9
Total	330	0	330	0

FLY BROOK.

"The Fly Brook is the furthest branch to the South-East of the Donnelly River, which discharges itself into the Southern Ocean, about 30 miles East of Cape Leeuwin. The river is always running, since there is a large rainfall in this portion of the Colony, but, unfortunately, it is not navigable, besides which the estuary at its mouth is closed by a sand bar; therefore, the nearest ports that ships could use are Augusta and Hamelin Harbour, about 30 miles

to the Westward. On this brook some coal-mining leases were taken up in the year 1888, but the existence of coal seams appears to have been known to some of the older inhabitants for many years. Several reports have been made, which show that four large seams of coal outcrop in the gully. These leases were tested in a systematic manner by a series of bore holes, to determine the number, size, quality, and extent of the seams, which were shown to extend over the whole area taken up, the large seams being easily identified when met with in the different holes by their persistent thickness, associated beds, and partings; but up to the present the entire thickness of this formation in the deep ground is unknown since there was so much water in drifts that the bore hole was continually falling in. One of the bores passed through about 20 feet of coal in sinking to a depth of 128 feet, consisting of 17 seams, the largest being 5 feet 4 inches with a 6-inch clay parting, 2 feet 4 inches with a 3-inch parting, and 2 feet 3 inches with a 2-inch parting. Other seams, up to a foot in thickness, could also be worked, since several occur close together separated only by shaly partings.

"The coal itself is a highly lustrous variety, having almost the appearance of jet, but lacking its hardness, while the woody structure is clearly visible in some pieces. Upon assay it proves to be almost identical in composition with the cretaceous coals of the Pacific coast of North America.

"The average of three samples of Fly Brook coal assayed in Melbourne and Adelaide is:—

Water	16·40
Volatile matter	38·23
Fixed Carbon	43·32
Ash	1·85

As the similar coal in America is used largely for steam and other purposes, there is no reason why this should not prove to be of value in the future. The distance from a port is a great drawback, whilst the large percentage of water the coal contains renders it too friable for much handling. It may be mentioned that the samples sent away were no test since they came out of the creek bed, being much weathered, and containing a very large quantity of water; therefore, the coal from a depth should not contain nearly as much.

"The coal-bearing series here consist of sandstone, grits, and clay beds (the latter of which are often micaceous) the whole being overlaid by a bed of ferruginous conglomerate, containing large water-worn pebbles of quartzite, quartz, and other metamorphic rocks. This bed is not met with in many places in the district, and probably forms the junction between the coal-bearing series and the crystalline rocks."

KIMBERLEY.

According to the researches of Mr. Woodward—

"It is also highly probable that coal will be found in the Northern portion of the Kimberley district, near Wyndham, where

the carboniferous series is largely developed in the quartzite and sandstone-capped flat-topped hills, with shale beds beneath, attaining an elevation of as much as 1,000 feet. These shale beds must be of great thickness, for in the well at the base of the Bastion Hill they were found to go down over 100 feet, whilst they are seen in sections in the side of the hill 700 or 800 feet. The only way to make certain whether coal beds do exist is by boring, which at the same time would probably secure a water supply for the town."

A bore was put down at the foot of Bastion Hill in 1897 to a depth of 690 feet, in the search of artesian water. The bore passed through* a series of hard sandstones and shales, but met with no coal seams. As the bore had not pierced the whole thickness of sedimentary strata, it cannot be said that the question of coal has been definitely settled.

BROWN COALS OF THE SOUTH COAST.

"Along the bold rough South coast, between Albany and Point D'Entrecasteaux, without shelter or harbours for even small vessels, stretches a narrow strip of calcareous country covered with abundance of herbage. This coast consists of bold headlands of granite or high cliffs of sandstone, which latter, when it forms capes, is always protected to a certain extent from the action of the sea by reefs or islands of rock. There are numerous inlets along this coast, but these are useless as harbours, since they are either too shallow or have their mouths barred, whilst they are gradually being filled up with mud by the running streams which discharge themselves into them. These inlets were at no very remote period permanently connected with the sea by wide and deep channels, but since the coast rose, the sand dunes which now form the cliffs were blown up, fringing the coast between the inlets and the sea, often completely blocking up their entrances.

"The only good harbour upon this coast is King George's Sound, where the natural features have protected its entrance from being closed up by sand. The inner, or Princess Royal Harbour, is, however, being rapidly filled in at its head by a sand drift, which is gradually creeping over the coastal hills. When this line of coast hills was first formed they were more continuous than they are now, but at the same time they were lower, whilst behind them was a low swampy flat or lagoon into which the streams from the North discharged themselves. In this lagoon accumulated large quantities of vegetable matter which gradually formed a peaty substance of the brown coal class. This coal is found to be of better quality in the middle of these basins, whilst towards the edges it consists almost entirely of sand; it is also overlaid by black sand which contains a very large quantity of vegetable matter."†

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* Report of the Department of Public Works for the Year 1897-98. Perth; By Authority; 1898.

† H. P. Woodward. Mining Handbook to the Colony of Western Australia; 2nd Edition. Perth; By Authority; 1895; pp. 145-146.

The same author pointed out, in a report upon the prospect of obtaining coal near Albany,* that a large basin surrounded by granite exists in the neighbourhood, but that boring operations alone could determine the presence of coal seams. For the purpose of testing this basin a bore was put down on the Eastwood Estate, $7\frac{1}{2}$ miles from Albany, on the Great Southern Railway Line.

The following is a section of the strata pierced:—

Nature of Strata.	Thickness.		Depth.	
	ft.	in.	ft.	in.
Sandy Peat	8	6	...	
Ferruginous Sandstone	1	0	8	6
Sand and Black Clay	5	6	9	6
Quicksand	5	0	15	0
Ferruginous Sandstone	0	1	20	0
Quicksand	30	0	20	1
Stiff Black Clay	4	0	50	1
Quicksand...	10	0	54	1
Brown Coal and Quicksand ...	3	0	64	1
Total	67	1	67	1

The bore collapsed at 67 feet, without the whole thickness of the beds having been obtained.

An analysis of the seam showed its composition to be—

Water	6·275
Volatile Matter	18·84
Fixed Carbon	14·835
Ash	60·05

Mr. Woodward reports†:—"The sample is of a dull sooty black colour, showing a good deal of vegetable structure. It is not highly mineralised, but fairly compact, soft, friable, and soils the hands. The fracture is irregular, showing a laminated structure. It does not ignite readily, but when made red hot it burns slowly, giving out a good deal of heat, and when ignited in a tube it gives off a small quantity of gas, tar, and water. The percentage of water is low for a coal of this class; the volatile matter, consisting of luminous and non-luminous gases, is also low, so is the fixed carbon, whilst the quantity of ash is enormous. The coke was in the form of a fine sooty powder, whilst the ash was light and of a creamy colour."

In 1899 further boring operations in the vicinity of Albany have been carried out, but so far without any great success.

A further reference is made by Mr. Woodward to the deposits of the South Coast, and a description given of the mode of occur-

* General Report for the Year 1892 etc. Perth: By Authority: 1893; pp. 3-4.
† *Loc. cit.*

rence and origin of lacustrine coals, which this author remarks occur :—

"In seams often of considerable size, with underlying shale beds, which latter contain roots and pieces of wood, with pyrites more or less decomposed, when it forms red ironstone nodules and alum shale, this latter being met with as efflorescences on the cliff faces. Above these coal beds are sandstone, often containing large quantities of carbonaceous matter, whilst the coal itself varies greatly in quality, often consisting largely of sand. There are no indications of true coal upon this coast; in fact, the granite basins seem to be filled entirely with these recent lacustrine and estuarine deposits. . . . These ancient basins are generally small, but even where large ones occur, as to the Northward of Albany, there are no indications which would lead one to hold out the least hope that true coal will ever be found here, because brown coal associated with sandstone, shale, and pyrites are no indication that the carboniferous formation exists, since these same rocks occur in many different modern formations."

GRAPHITE.

Graphite has been found in association with certain ferruginous deposits in the Champion Bay District, but proved to contain too large a percentage of iron to be of any remarkable value.

A deposit of graphite was worked in the neighbourhood of Kendenup; the graphite proved to be of fair quality, but the distance from market proved an insuperable bar to its economic working.

" Some years ago a deposit of graphite (plumbago) was discovered near the head of the Donnelly River, about 10 miles East of Dickson's, on the Lower Blackwood Road, and between eight and ten miles South of Nelson Grange, the property of Mr. Allnut, a few miles from Bridgetown. About six years ago a syndicate was formed at the Vasse, which took up and prospected several blocks, but the price of graphite at the time was so low that the work was abandoned before much had been done. Early in the year 1894 Mr. Knox Brown reported that he had discovered apparently payable plumbago on a protection area which he had taken up near the older find. This latest discovery is situated between two creeks which flow in deep valleys, from one of which a drive to the North has been put in to the side of the ridge, at right angles to the outcrop of the deposit, with the result that three beds were passed through. The first of these which outcrops near the mouth of the drive is 28 feet in thickness, being followed by 13 feet of schistose rock, containing a small bed 1 foot 6 inches in thickness, whilst the third bed is 8 feet in thickness. Several other shafts have been sunk, and open cuttings made to test the run of these beds. From one of the former, about four chains to the Westward of the drive, which appears to be upon the large bed, a sample, weighing 25cwt., was sent to England in order to ascer-

tain its commercial value. In another shaft, about 15 chains further up the spur to the Westward, at an elevation of about 100 feet above the mouth of the drive, the deposit was again struck at a few feet from the surface. These beds should, correctly speaking, be called plumbaginous schists, since the percentage of graphite contained is so small, the main portion of the deposit consisting of a magnesian silicate. The formation consists principally of micaceous and talcose schists, which here strike East and West, dipping at a high angle to the Northwards; whilst following along to the Southward, close to the outcrop of the graphite beds, is a large dyke of intrusive granite. A little to the Eastward of the drive, at the junction of the two creeks, the outcrop of this deposit is lost, but beds of steatite are met with along this line as far as Wilgarup; therefore the graphite seams will also probably be found to extend in this direction, the local break in the continuity of the rocks being due in all probability to a fault. To the Westward the graphite can be traced for several miles, but the beds seem to split up and become smaller upon the claims that were first prospected. This deposit of earthy graphite is due to the alteration of poor shaley coal seams, the metamorphosis being in all probability due to the indurated granite to the Southward which changed the coal seams into graphite and the shale into schists. It offers exceptional facilities for cheap working, since the spur upon which it is situated rises so rapidly that a drive following the strike from the outcrop in the creek would have 100 feet of backs in a distance of about 20 chains; whilst if crosscuts were driven about five chains from the valley which runs parallel to the strike the seam would be obtained. The firm of crucible makers to whom the sample was sent reported it to be of no commercial value, but since graphite is put to a multitude of uses at the present day, in most of which forms it is largely adulterated with earthy matter, and so long as our deposit does not contain any deleterious substance, it should certainly be of some value. When we consider the large size of the deposit, the cheapness with which it could be worked, its short distance from good roads, the enormous quantity of karri timber on the spot of almost any length, and the perpetual supply of running water, it should certainly, if not at present, prove in the near future to be of great value." *

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*Woodward, H. P. The South-Western portion of the Colony. Appendix 1. Report of the Department of Mines for the Year 1894. Perth; By Authority: 1895; p. 9.

CHAPTER X.

GUANO DEPOSITS.

General — Houtman's Abrolhos Islands — Analyses of Western Australian Guano—Production of Western Australian Guano.

While perhaps the accumulations of guano occurring in the Abrolhos Islands and elsewhere in the North, formed as they are by organic agencies, may not in a strictly scientific sense be mineral deposits, their economic importance is a sufficient justification for referring to them in a description of the mineral resources of the Colony.

That the importance of these deposits is considerable may be judged from the appended table of Statistics, showing the production of guano in the Colony, as prepared from official data. No record would appear to have been kept of the quantity of guano raised previous to the year 1847, also during the years 1847 to 1855, 1855 to 1865, 1865 to 1872, 1872 to 1876, and also the years between 1879 and 1882. From the official figures it appears that since 1847, 81,978 tons of guano have been raised, and that the total royalty paid to the Government from that date amounted to £38,861. From the year 1847, as shown by the Customs figures, 76,766 tons of guano, valued at £313,323, have been exported from the Colony.

Up to the present time the chief source of the guano raised is in Houtman's Abrolhos Islands, West of the town of Geraldton.

"Houtman's Rocks or Houtman's Abrolhos consists of a little archipelago, for the most part of coral formation, situated between latitudes 28° 15′ and 29° South, some 30 miles off the mainland coast of Western Australia and immediately opposite Champion Bay and the thriving port of Geraldton. More closely examined the Abrolhos Archipelago is found to be separable into four secondary groups, characterised in order from North to South, as the North Island, Wallaby, Easter, and Pelsart Groups. With the exception of the Wallaby Group, which contains plutonic rocks corresponding in character with those of the mainland, and having an elevation of some 30 or 40 feet, the larger residue is entirely of coral formation, while reefs of considerable extent also encircle the Wallaby Series. Their composition, as manifested more particularly in the islets of the Easter and Pelsart Groups, consists of hard coral limestone conglomerate, undermined and weathered on its exposed aspects into low overhanging cliffs and promontories often of the most fantastic shape, which frequently show embedded in their eroded surfaces but slightly altered Corolla of the Madreporidæ of which they are principally composed. . . . . . From time immemorial, as testified to by the deep guano deposits, Houtman's Abrolhos has been the home or breeding centre of countless hosts of sea birds, which still resort thither in enormous quantities in the breeding season. . . . . . On account of the vast accumulations of guano resulting from the sea-birds having so long made the

Abrolhos their headquarters, this island group possesses a considerable commercial value."*

In August, 1897, Mr. Licensed Surveyor Wells was despatched from Geraldton to the Abrolhos Islands for the purpose of officially estimating the quantity of guano still available on the Group. † This officer visited 10 islands of the Eastern group, and on four of them, viz., Rat, Third Beacon, and Wooded Islands found guano deposits varying from 4 inches to 27 inches in thickness. The islands of the Eastern Group are estimated to contain 13,944 tons of guano. Of the 14 islands of the Pelsart Group examined, nine were found to contain guano deposits, viz., Pelsart, Gun Island, and seven small islands adjacent. The deposits varied from 7 inches to 13 inches in thickness; the group is supposed to contain 48,468 tons of guano. Mr. Wells examined 18 islands of the Wallaby Group, but only made surveys of four, viz., West Wallaby, Pelican Island, and North and South Pigeon Islands. These were estimated to contain 38,088 tons of guano varying in thickness from 4 inches to 17 inches. Small quantities of guano occur in several of the lesser islands.

Twenty-three analyses of the Abrolhos Guano have been made and are given in the table annexed.

Analyses of Abrolhos Guano.

No.	Sand.		Moisture.		Phosphates.	
	A.	B.	A.	B.	A.	B.
1	7·14	10·63	4·13	5·36	55·01	55·51
2	6·04	5·86	6·65	7·33	50·54	49·23
3	8·20	8·10	4·32	5·73	58·09	55·23
4	0·80	0·63	5·45	7·76	67·98	66·15
5	0·79	0·96	7·23	8·36	60·88	59·71
6	0·80	1·56	4·07	5·73	69·40	67·13
7	3·36	2·70	5·12	6·86	68·28	63·50
8	0·93	0·96	6·28	7·66	68·84	64·83
9	1·71	0·46	6·72	9·23	62·67	67·13
10	0·72	1·46	6·56	9·60	73·17	58·17
11	2·08	1·85	4·00	5·01	77·40	72·14
12	0·41	0·50	9·37	7·63	69·26	65·71
13	0·36	0·43	6·80	7·93	69·68	65·60
14	0·85	0·30	8·61	10·06	51·38	46·50
15	0·48	0·56	8·16	11·23	55·43	51·73
16	0·26	0·23	6·37	8·06	54·73	51·95
17	1·40	1·40	5·40	6·56	66·46	62·17
18	0·16	0·15	7·56	16·03	61·72	56·65
19	3·96	3·63	7·01	9·60	48·31	46·28
20	6·04	4·73	8·90	11·60	53·90	50·20
21	0·64	1·01	4·37	2·53	63·53	61·12
22	13·83	13·30	4·72	3·56	64·51	51·94
23	4·81	4·63	3·74	2·90	69·82	64·07
Mean	**2·86**	**2·87**	**6·15**	**7·66**	**62·65**	**58·81**

A. Analyst.—S. S. Dougall, Perth, Western Australia.
B. Analyst.—John Hughes, London, England.

* Saville-Kent, W. The Naturalist in Australia. London, 1897; pp. 135-137

† A. J. Wells. Report on the Abrolhos Islands Guano Deposits. Perth By Authority: 1897.

The Production of Guano in Western Australia.

Year.	Guano Raised.									Guano Exported.				
	Quantity.		Total Value.			Total Royalty Paid.				Quantity.		Total Value.		
	tons	cwt.	£	s.	d.	£	s.	d.		tons	cwt.	£	s.	d.
1847	*		*			*				3	0	18	0	0
1855	*		*			*				25	0	125	0	0
1865	*		*			*				35	0	175	0	0
1872	*		*			*				52	0	107	0	0
1876	2534	0	...			1267	0	0		735	0	367	10	0
1877	14355	0	...			7177	10	0		1212	0	6060	0	0
1878	19865	3	...			9932	11	6		13219	0	66095	0	0
1879	*		*			*				12041	0	54184	0	0
1880	*		*			*				1330	0	6650	0	0
1881	*		*			*				*Nil*				
1882	*		*			*				*Nil*				
1883	724	0	...			362	0	0		456	0	2964	0	0
1884	2505	0	...			2012	5	11		1163	0	7559	10	0
1885	973	0	...			311	11	4		528	0	3432	0	0
1886	2631	0	...			1654	3	0		10157	10	66023	15	0
1887	3360	0	...			2052	14	0		3158	0	20527	0	0
1888	3582	0	...			1433	12	0		3110	0	12440	0	0
1889	3583	0	...			1697	10	0		3395	0	8488	0	0
1890	4038	0	...			1956	10	0		3913	0	9783	0	0
1891	6225	0	...			2858	10	0		6251	0	15628	0	0
1892	2569	0	...			1355	13	4		2508	0	4384	0	0
1893	3297	0	...			1570	0	0		4030	0	7052	0	0
1894	2001	0	...			969	10	0		2239	0	3919	0	0
1895	1945	0	...			544	0	0		100	0	200	0	0
1896	1618	0	...			191	5	0		1660	0	4506	0	0
1897	2569	0	...			331	6	0		1496	5	3250	0	0
1898	3604	0	...			1278	14	11		3950	0	9386	0	0
1899	2092	4	...			743	5	1		2045	10	5165	0	0
Totals	**84070**	**7**	...			**39699**	**12**	**1**		**78812**	**5**	**318488**	**15**	**0**

* No records.

CHAPTER XI.

ARTESIAN WATER.

Artesian Wells, Records of Bores, Analyses of Artesian Water.

In its broader topographical features, Western Australia falls naturally into three geographical divisions:—

(*a.*) The Coastal Plain. This consists in reality of a fringe of strata around the coast, with a more or less gentle slope to the seaward. The plain is formed for the most part of shallow water deposits, sandstones, conglomerates, and thin shales, with occasionally incoherent sand and clays. The Plain has a width of 60 or 70 miles in places on the Western Coast, though in the country at the head of the Great Australian Bight, the Plain, absolutely devoid of rivers, extends some 200 miles into the interior. The inner margin of the Coastal Plain reaches an altitude of 600 feet above sea-level in certain localities. The Coastal Plain is separated from the interior by a belt of

(*b.*) Hill Ranges, which form what may be called the escarpment of the Plateaus and Plains of the Interior. The Hill Ranges have an average elevation of about 1,200 feet, though isolated Ranges reach altitudes of 4,000 feet above sea-level. This escarpment has either a short or steep slope down to the edge of the Coastal Plain, into which it gradually merges. This belt of country, drained by the rivers of the Colony, is formed of granitic and metamorphic rocks, the decay of which produces excellent soil; it comprises, owing to its rainfall, the principal Agricultural Districts of the Colony.

(*c.*) The Plateaus and Plains of the Interior consist of a broken tableland, from which rise isolated hills and ridges of metamorphic rocks, often separated by sand-plains of some considerable extent, and containing depressions occupied by saline marshes, clay flats, brine lakes or deposits of salt. There are no rivers, and the rainfall is slight. This plateau forms the chief mineral region of the Colony.

The Coastal Plain is of considerable economic importance, in that the certainty of obtaining artesian water from the underlying strata has now been thoroughly established. The system of boring for artesian water, however, is capable of great expansion in the Colony, and is limited only by locality.

A glance at any Geological Map of Western Australia shows an enormous extent of Recent and Tertiary Strata entering the Colony at its Eastern border, in the Nullabor Plains, and extending without any interruption as far as Israelite Bay. These strata consist of porous limestones associated with beds, into which the rainfall is rapidly absorbed and discharged seawards in the form of fresh water springs. Where these strata have been pierced on the South Australian side of the border, the section invariably shows from 300ft. to 500ft. of sandy water-bearing beds, of undetermined age, covered by a variable thickness of calcareous strata of both Older and Newer Tertiary age. The beds have a prevailing dip towards the Great Australian Bight, and water rises in the bore holes to a height equal to that of the sea level. So far, however, the water obtained has proved to be either salt or brackish, but at any rate suitable for stock purposes.

The whole of the area of these beds in the Southern portion of this Colony may be described as an artesian water area, though there may be, and undoubtedly are, conditions affecting the water supply, such as local variations in the thickness, the relative porosity of the beds, and the unevenness of the floor upon which they were laid down, which, with our present meagre knowledge, can only be set at rest by the operations of the drill.

The strata of the Coastal Plain in the vicinity of the Swan River have proved that in certain areas they possess all the conditions necessary for yielding an overflowing supply of water. The structure of the Coastal Plain differs in some respects from the typical areas in which artesian water has been obtained in the Eastern portions of Australia. The strata are horizontal or nearly so, though occasionally there is a slight local dip of about five degrees in places. The effect of this horizontality is shown in the fact that the water-carrying beds do not crop out on the surface at the foot of the Darling Range, but impinge directly against that portion which is now concealed from view. These beds, clays (marls ?), and sandstones with occasional limestones, do not maintain an uniform thickness throughout, but are disposed in the form of lenticular beds, some of which appear to be of exceptionally absorbtive properties.

The bores which have already been put down between the Darling Range and the Coast have shown how irregular are the strata from which the water has been obtained, and what is of further moment, they also demonstrate that only in one instance has the base of the water-carrying beds been reached.

The first supply of artesian water in the vicinity of Perth, was obtained some time during the year 1873, in a bore put down in the

search for coal, under the advice of Mr. H. Y. L. Brown, then Government Geologist. The situation of the bore was somewhere near the Canning River, a few miles South-East of Perth, and close to the foot of the Darling Range. The following is a description of the material brought up from time to time, as determined by Mr. Brown:—

Canning River Bore.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Sand, gravel, sandy clay, and small boulders of igneous rocks, clay containing pyrites	16 0	...	"The sand and gravel in the above list, with the exception of that near the surface, must be considered mostly as coming from beds of sandstone and conglomerate which have been worked up by the action of the boring tools. In the same way the black and blue clay, when *in situ*, existed as shale. It is more than probable again that the rounded fragments brought up from certain depths had previously fallen down from a higher position."* Artesian water is still flowing from this bore.
Rounded granite pebbles, and gravel, grit, blue clay and shale containing carbonised matter	25 0	16 0	
Gravel, sand, and pieces of quartz and granite; black clay with pyrites	23 0	41 0	
Rounded quartz, granite, grit, quartzite, and black clay with pyrites	29 0	64 0	
Rounded pieces of granite, and igneous rocks, gravel, sand, quartz, etc., with fragments of lignite	33 0	93 0	
Rounded fragments of igneous rocks, sand, etc.; yellow sandstone at 139 feet; coarse grit and sand at 171 feet	45 0	126 0	
Total	171 0	171 0	

In the year 1885, Mr. E. T. Hardman, of Her Majesty's Geological Survey of Ireland, who at that time acted as Government Geologist, dealt fully with the question of supplying the city of Perth with artesian water, and after dealing with the principles of the construction of artesian wells, concluded that it would be hopeless to expect an overflowing supply of water anywhere in the neighbourhood. This conclusion is the only one which could be legitimately arrived at so long as it was assumed that the water-carrying strata must be arranged in the form of one of those ideal basins, sections of which have done duty for many years in geological manuals. Recent observations have shown that this condition rarely obtains in Nature, and that in all the important artesian areas, the porous beds are so arranged that there is only one side of a synclinal trough present, and the water has abundant facilities for escape at a much lower level than that at which it is received.

So far, in this Colony, what may be called a true artesian basin is on the Collie River, where a copious supply of water is at

* H. Y. L. Brown: On a geological exploration to the N.E. of Champion Bay, Western Australia. Perth: By Authority, 1871; pp. 10-11.

present flowing from Bores Nos. 2 and 3, put down with the object of testing the coal measures; details in connection with these can be seen by a reference to Chapter IX., above. From observations which have been made it would seem that the amount of water flowing from the bores on the Collie River increases and diminishes in a manner which points to dependence upon seasonable variations.

All the available information about artesian wells has been collected and tabulated for convenience of reference. So far, as official data show, there are 16 artesian wells in the Colony, reaching an aggregate depth of 14,165 feet, yielding a total flow of 4,806,504 gallons per diem, which is equivalent to 1,754,373,960 gallons per annum. In addition to these there are three sub-artesian wells, of an aggregate depth of 2,511 feet, from which 531,700 gallons of water can be pumped daily, or 194,070,500 gallons per annum.

The Pound (near the Railway Station, Perth).

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Clay	38	0	...		
Coarse sandstone	27	0	38	0	
Clay	18	0	65	0	
Dark grey sandstone	18	0	83	0	
Clay	9	0	101	0	
Soft sandy marl	110	0	110	0	
Total	220	0	220	0	

West Perth Railway Station.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Drift sand	36	0	...		Altitude of bore, 37·71 feet above sea level. Yields 500,000 gallons per diem. Hydrostatic head, 77·71 feet above sea level; and 40 feet above surface. Hydrostatic pressure, 17·32lbs. per square inch.
Clay	14	0	36	0	
Drift sand (incoherent sandstone)	9	0	50	0	
Clay	4	0	59	0	
Coarse drift (incoherent sandstone)	25	0	63	0	
Sandstone and clay	20	0	88	0	
Sandstone (with thin bands of shale)	718	0	108	0	
Total	826	0	826	0	

Subiaco Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Sand...	40	0	...		Altitude of bore, 117·15 feet above sea level. This bore was started from bottom of shaft, which is 103 feet deep. Sub-artesian water obtained; water rose in the bore to within 45 feet of natural surface. At 52 feet below the surface the overflow into the shaft is 161,000 gallons per diem. At 67 feet 10 inches below the surface the overflow into the shaft is 450,000 gallons per diem. Static head, 72 feet above sea level.
Sandstone with hard bands ...	63	0	40	0	
Sand and boulders	67	0	103	0	
Conglomerate (very hard) ...	10	0	170	0	
Soft sandstone	178	0	180	0	
Clayey and sandy shales ...	210	0	358	0	
Drift sand (incoherent sandstone)	98	0	568	0	
Clayey shale	60	0	666	0	
Soft sandstone	150	0	726	0	
Total	876	0	876	0	

Perth Racecourse Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Sandy clay...	29	0	...		Altitude of bore, 40 feet above sea level. Yields 536,000 gallons per diem. Hydrostatic head 58·69 feet above sea level, and 18·69 feet above surface. Hydrostatic pressure, 8lbs. per square inch.
Yellow sand	11	0	29	0	
Stiff clay	4	0	40	0	
Sandstone	264	0	44	0	
Sandy shale with bands of sandstone	154	0	304	0	
Sandstone	309	0	458	0	
Sandstone with bands of clay shale	332	7	767	0	
Total	1,099	7	1,099	7	

Leederville Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Sand (incoherent sandstone) with three bands	130	0	...		Yield, 288,000 gallons per diem. Pressure in lbs. per square inch 4·75. Static head above surface in feet 11·33. Surface of ground above sea level 58·85 feet. Depth of principal water-bearing strata, 1,023 feet.
Calcareous sandstone	23	0	130	0	
Limestone	5	6	153	0	
Calcareous sandstone	47	6	158	6	
Shell marl	691	6	206	0	
Sandstone	8	6	897	6	
Calcareous shales with one band of calcareous sandstone ...	103	4	906	0	
Calcareous sandstone with two bands of sandstone	104	11	1,009	4	
Total	1,113	3	1,113	3	

South Perth Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Sand (incoherent sandstone ?) ...	75	0	...		Output, 372,384 gallons per diem. Pressure in lbs. per square inch 44·5. Static head above surface in feet 102·75. Surface of ground above sea level 18·01 feet. Depth of principal water-bearing strata, 1,837 feet.
Calcareous shale	142	0	75	0	
Sand (incoherent sandstone?) ...	263	0	217	0	
Calcareous shales with five (5) hard bands	1,351	0	480	0	
Sand (incoherent sandstone) ...	29	6	1,831	0	
Total	1,860	6	1,860	6	

Melville Water Park Estate Bore.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
White sand	31	0	...		Altitude of bore, 9·44 feet above sea level. Yields 140,000 gallons per diem. Hydrostatic head, 49 feet above sea level; and 39·56 above surface. Hydrostatic pressure, 17lbs. per square inch. Temperature of water, 91° Fahrenheit.
Sands and clays	184	0	31	0	
Sandy calcareous shales with fossils	78	0	215	0	
Sandstone	15	0	293	0	
Sandy shale	59	6	308	0	
Sandstone	77	6	367	6	
Sandy shale, with occasional calcareous bands	947	6	445	0	
Drift sand and shale, with nodules of pyrites and quartz boulders	16	0	1,392	6	
Sandstone and grit	78	6	1,408	0	
Granite	3	6	1,486	6	
Total	1,490	0	1,490	0	

Water Hall Estate Bore, Guildford (J. Morrison).

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Dark soil	3	0	...		Altitude of bore, 35·02 feet above sea level. Yields 200,000 gallons per diem. Hydrostatic head, 46 feet above sea level, and 10·98 feet above surface. Hydrostatic pressure, 4·75lbs. per square inch.
Clay, gravel, and cement ...	47	0	3	0	
Clay	77	0	51	0	
Sandstone (drift sand)	105	0	128	0	
Clay shale	30	0	233	0	
Sandstone with band of shale ...	126	0	263	0	
Clay shale	67	0	389	0	
Alternations of sandstone and clay shale	235	0	456	0	
Total	691	0	691	0	

Bebo Moro Bore, Guildford (H. E. B. Gull).

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Clay	6	0	...		Altitude of bore, 19·46 feet above sea level. Yields 80,000 gallons per diem. Hydrostatic head, 37 feet above sea level, and 17·54 feet above surface. Hydrostatic pressure, 7·50 lbs. per square inch.
Sand and clay	62	0	6	0	
Sandstone	96	0	68	0	
Clay	101	0	163	0	
Loam and sand	7	0	264	0	
Black clay	39	0	271	0	
White sand (? incoherent sandstone)	8	0	310	0	
Black clay	33	0	318	0	
Clay and loam	5	0	351	0	
Drift sand (? incoherent sandstone)	52	0	356	0	
Ironstone gravel	...		...		
Total	408	0	408	0	

Woodbridge Estate Bore, Guildford (C. Harper).

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Dark loam	10	0	...		Altitude of bore, 14·30 feet above sea level. Yields 150,000 gallons per diem. Hydrostatic head, 33 feet above sea level, and 18·30 feet above surface. Hydrostatic pressure, 7·92 lbs. per square inch.
Drift sand (? incoherent sandstone)	59	0	10	0	
Clay and loam	60	0	69	0	
Drift sand (? incoherent sandstone)	18	0	129	0	
Clay and loam	12	0	147	0	
Drift sand	76	0	170	0	
Total	235	0	235	0	

Municipal Bore at Guildford.

Nature of Strata.	Thickness. ft.	in.	Depth. ft.	in.	Remarks.
Blue and yellow clays and gravel	34	0	...		Altitude of bore, 11·37 feet above sea level. Yields 1,120,000 gallons per diem. Hydrostatic head, 64·55 feet above sea level, and 53·18 feet above the surface. Hydrostatic pressure, 23lb. per square inch.
Sand...	6	0	34	0	
Black clays	10	0	40	0	
Sand and water-worn pebbles ...	25	2	50	0	
Black sandy clay	147	7	75	2	
Sand and sandstones impregnated with pyrites	792	3	222	9	
Sand with layers of shale ...	187	0	1,015	0	
Total	1,202	0	1,202	0	

Lockeridge Estate Bore, Guildford (H. Hamersley).

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Surface *débris*	1	6	...		Altitude, 14·29 feet above sea level. Yields 123,000 gallons per diem. Hydrostatic head, 21 feet above sea level, and 7 feet above surface. Hydrostatic pressure, 3·03lbs. per square inch.
Clay and sandstone bands ...	13	6	1	6	
Drift sand (? incoherent sandstone)	25	0	15	0	
Clay (? shale)	16	0	40	0	
Sand (? incoherent sandstone) ...	27	6	56	0	
Decomposed ironstone	2	0	83	6	
Dark clay shales with coal veins	146	0	85	6	
Sand (? incoherent sandstone) ...	7	6	231	6	
Clay shale	12	0	239	0	
Drift sand (? incoherent sandstone)	10	0	251	0	
Clay shale	14	0	261	0	
Drift sand (? incoherent sandstone)	28	0	275	0	
Clay shale	16	0	303	0	
Drift sand (? incoherent sandstone)	50	0	319	0	
Sandstone (with three thin bands of clay shale)	304	0	369	0	
Clay shale	32	0	673	0	
Sand (? incoherent sandstone) ...	8	0	705	0	
Clay shale	23	0	713	0	
Sand (? incoherent sandstone, with bands of clay shale)	62	0	736	0	
Total	798	0	798	0	

Midland Junction Bore.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Sand and clay ...	21	0	...		Altitude of bore, 13 feet above sea level. Between 60 feet and 71 feet, 5,000 gallons of water per diem rose to 4 feet above the surface. Between 98 feet and 107 feet, 8,900 gallons per diem rose to 5 feet above the surface. Between 166 feet and 246 feet, water at the rate of 129,600 gallons per diem overflowed with a hydrostatic head of 12 feet. Between 262 feet and 350 feet water at the rate of 151,000 gallons per diem overflowed with a hydrostatic head of 18·7 feet. Between 363 feet 6 inches and 419 feet, water at the rate of 100,000 gallons per diem overflowed with a hydrostatic head of 18·7 feet. The water-bearing beds, which are being drawn upon for the Midland Junction supply, are those between 262 feet and 350 feet, and 363 feet and 420 feet. All the others are shut off. Hydrostatic pressure, 8·66lbs. per square inch.
Sandstone	86	0	21	0	
Sandy shale ...	59	0	107	0	
Grey sandstone ...	80	0	166	0	
Arenaceous clay shale	16	0	246	0	
Grit and clay shale	88	0	262	0	
Clay shale ...	13	0	350	0	
Sandstone and clay shale	56	0	363	6	
Clay shale ...	81	0	419	0	
Total ...	500	0	500	0	

Several bores have been put down in the neighbourhood of Bunbury, and artesian water obtained at comparatively shallow depths. Southwards from Point Casuarina, and to the West of

the town, is a narrow fringe of columnar basalt rising from beneath the sea level, but forming no conspicuous elevation. Basalt is, however, known at Black Point, and at one or two places on the mainland between that place and the town of Bunbury. To the basalt succeeds a long irregular line of sand dunes, upon the highest point of which, Marlston Hill, the light-house is placed. By far the larger portion of Bunbury, however, is built upon an extensive alluvial flat, whose surface is raised but little above the high-water mark.

Bore No. 1, situate at the Eastern end of Stephen Street, and about half-a-mile West of the outcrop of the basaltic lava, was carried down to a depth of 30ft. The drill entered the basalt after passing through 10ft. of superficial deposits, and was carried down through it for a further distance of 20ft., when operations ceased, there being some doubts as to whether the rock was disposed in the form of a bed or beds. The section in bore at the Bunbury Brewery, below Marlston Hill, proves that the basalt is in the form of beds, but boring operations have not been carried deep enough to show whether the clay beneath the lava is merely a thin bed dividing two individual lava flows, or is the old floor upon which the basalt was laid down.

The following are the particulars in connection with the strata pierced in these bores, together with other cognate points:—

Bunbury Bore No. 1.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Superficial deposits	10	0	...		Bore abandoned. No water.
Basaltic Lava	20	0	10	0	
Total	30	0	30	0	

Bunbury Bore No. 2.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Surface clay	2	0	...		Altitude of bore, 2 feet above sea level. At a depth of 97 feet a sub-artesian supply, capable of yielding 70,000 gallons per diem was encountered.
Black clay	7	0	2	0	
Sand	2	4	9	0	
Cement	0	3	11	4	
Coarse sand	5	5	11	7	
Yellow clay	2	0	17	1	
Sand	5	0	19	0	
Hard yellow clay	2	6	24	0	
Coarse white sand	5	0	26	6	
Cemented sand	0	3	31	6	
Stiff dark clay	3	9	31	9	
Coarse sand and gravel	21	9	35	6	
Cemented sand	3	0	57	3	
Sand	5	0	57	6	
Yellow clay	5	0	62	6	
Sand	36	6	67	6	
Total	104	0	104	0	

Bunbury Bore No. 3.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Clay	10 0	...	Altitude of bore, 2 feet above sea level. The sandstone at 86 feet yielded an overflowing supply of 10,000 gallons per diem. The principal supply is drawn from the sand at the bottom of the well. The total yield is 100,000 gallons per diem. Hydrostatic head untested.
Yellow sand	14 0	10 0	
Ironstone conglomerate	0 10	24 0	
Hard clay	4 0	24 10	
Sand and cement	2 0	28 10	
Soft sandstone	2 0	30 10	
Clay (shale ?)	5 0	32 10	
Sandstone	8 0	37 10	
Clay (shale ?)	8 0	45 10	
Sandstone	13 0	53 10	
Clay (shale ?)	4 0	66 10	
Sandstone	23 0	70 10	
Yellow clay (shale ?)	6 0	93 10	
Coarse sand (incoherent sandstone)	18 0	99 10	
Hard yellow clay (shale ?) ...	16 0	117 10	
Coarse sand (incoherent sandstone)	17 0	133 10	
Yellow clay (shale ?)	5 0	150 10	
Coarse sand (incoherent sandstone)	25 0	155 10	
Sandstone	68 0	180 10	
Gravel (conglomerate ?)	2 0	248 10	
Soft yellow clay (shale ?) ...	2 0	250 10	
Drift sand (incoherent sandstone)	23 0	252 10	
Gravel (conglomerate)	1 0	275 10	
Blue pipeclay (shale ?)	32 0	276 10	
Drift sand (incoherent sandstone ?)	71 0	308 10	
Pipeclay (shale ?)	0 6	379 10	
Drift sand (incoherent sandstone)	36 6	380 10	
Total	416 8	416 8	

Bunbury Brewery Bore.

Nature of Strata.	Thickness.	Depth.	Remarks.
	ft. in.	ft. in.	
Sand and surface *débris*	12 0	...	The bore was commenced at the foot of a well, and a depth of 112 feet from the surface attained. The water, which rises to about the top of the basalt at a depth of 12 feet from the surface, is of excellent quality, and is said to be well suited for brewing purposes.
Basalt	97 0	12 0	
Clay	3 0	109 0	
Total	112 0	112 0	

The beds of the Coastal Plain further to the North, in the neighbourhood of Geraldton, have been explored by means of bores. Three bores have been put down, two at Geraldton, and one at Dongara, near the mouth of the Moore River.

The country in the vicinity of Geraldton is composed of sandy limestones, very little disturbed from the position in which they were originally laid down. The calcareous strata are in places covered with deposits of blown sand. To the East of Geraldton the limestones rest upon the old crystalline rocks, which are absolutely impervious to water below the zone of decomposition. Owing to the horizontality of the strata the basal beds of the Coastal Limestone series do not crop out anywhere near the junction of the limestone and the older rocks, but merely abut against the underground continuation thereof. Horizontal tablelands of grit and conglomerate, resting on granite and gneissic rock, form conspicuous landmarks in the neighbourhood. Some of the tablelands rise to considerable elevations above the level of the surrounding country. Many of the grits are sufficiently open and porous to be capable of absorbing and transmitting water were they disposed in such a way as to admit of this.

A bore was put down in the station yard at Geraldton, and operations were continued to a depth of 420 feet, when the old granitic floor was reached. The strata pierced, as can be seen by the following section, were shales and sandstones of the ordinary type; none of the beds yielded a supply of artesian water.

Geraldton Station Yard Bore.

Nature of Strata.	Thickness. ft.	Thickness. in.	Depth. ft.	Depth. in.	Remarks.
Sand	24	0	...		Altitude, approximately, 10 feet above sea level. No water.
Conglomerate	42	0	24	0	
Soft sandstone	10	0	66	0	
Conglomerate	15	0	76	0	
Sandstone	10	0	91	0	
Shale	3	0	101	0	
Sandstone and shale	25	0	104	0	
Conglomerate	0	4	129	0	
Coal	0	10	129	4	
Sandstone	4	0	130	2	
Clay with coal veins	3	6	134	2	
Coarse white sand with boulders	23	0	137	8	
Clay with coal veins	0	10	160	8	
Clay	5	0	161	6	
Pyrites [?]	2	1	166	6	
Grey shale	29	0	168	7	
Sandstone with coal veins ...	9	0	197	7	
Sandstone [soft]	20	0	206	7	
White clay	12	0	226	7	
Pyrites [?] and boulders	2	0	238	7	
Sandstones and pyrites	5	0	240	7	
Sandstone	6	0	245	7	
Clay	25	0	251	7	
Sandstone and shale	42	0	276	7	
White clay	5	0	318	7	
Clay with sandstone and pyrites [?], in bands	32	0	323	7	
Clay	17	0	355	7	
Blue shale	45	0	372	7	
Granite	2	6	417	7	
Total	420	1	420	1	

The scene of boring operations was eventually shifted to the Racecourse at Geraldton, and a depth of 1,153 feet obtained. The section herewith shows the nature of the strata pierced, and also proves the existence, hitherto unsuspected, of a subterranean granitic ridge, which, on carefully weighing all the evidence, seems to trend generally North and South. The following are the particulars in connection with the strata pierced:—

Geraldton Racecourse Bore.

Nature of Strata.	Thickness of strata.		Depth from surface.		Remarks.
	ft.	in.	ft.	in.	
Clays	5	0	...		Altitude of bore, 82 feet above sea level. A pumping supply of 11,700 gallons of very salt water met with at a depth of 72·9 feet. The water rose to a height of 45 feet below the surface.
Red and yellow sands	29	0	5	0	
Red clay	2	0	34	0	
Gravel	0	6	36	0	
Blue and red clays	7	6	36	6	
Red gravel with fragments of decomposed limestone ...	5	0	44	0	
Sand...	4	0	49	0	
Blue clays	12	0	53	0	
Sand with small bands of clay and pyrites intermixed ...	72	0	65	0	
Drift sand (incoherent sandstone)	13	6	137	0	
Ferruginous conglomerate ...	3	6	150	6	
Sandstone	12	0	154	0	
Clay...	1	0	166	0	
Sandstone	19	0	167	0	
Shell limestone	21	0	186	0	
Sandstone	4	0	207	0	
Shell limestone	5	0	211	0	
Blue clay	5	0	216	0	
Shell limestone	3	0	221	0	
Sandstone	3	0	224	0	
Loose sand [incoherent sandstone] with bands of shale intermixed ...	4	0	227	0	
Shell limestone	2	0	231	0	
Conglomerate	6	0	233	0	
Sandstone with bands of shell, shale, and pyrites	57	0	239	0	
Conglomerate containing petrified wood	1	0	296	0	
Sandstone containing bands of shale and pyrites	39	0	297	0	
Sandstone [incoherent sandstone ?] with coal-seams intermixed	8	0	336	0	
Sandstone containing bands of shale	13	0	344	0	
Conglomerate	12	0	357	0	
Dark shale	5	0	369	0	
Coal seam	0	6	374	0	
Dark shale	3	0	374	6	
Conglomerate	1	6	377	6	
Shale with bands of coal intermixed	14	0	379	0	
Argillaceous sandstone with bands of pyrites	7	0	393	0	
Limestone with bands of grey shale	20	0	400	0	

Geraldton Racecourse Bore—continued.

Nature of Strata.	Thickness of strata. ft.	in.	Depth from surface. ft.	in.	Remarks.
Dark shale	10	0	420	0	
Limestone with bands of light grey shale	16	0	430	0	
Shale with fragments of coral limestone	3	0	446	0	
Limestone	6	0	449	0	
Dark shale with bands of sandstone	32	0	455	0	
Shale	3	0	487	0	
Sand [incoherent sandstone?] ...	40	0	490	0	
Conglomerate	2	0	530	0	
Sand [incoherent sandstone?] ...	9	0	532	0	
Conglomerate	9	0	541	0	
Shale	2	0	550	0	
Conglomerate with bands of pyrites	43	0	552	0	
Sand [incoherent sandstone?] ...	10	0	595	0	
Fine silt	13	0	605	0	
Conglomerate	10	0	618	0	
Sandstone	12	0	628	0	
Argillaceous limestone	45	0	640	0	
Conglomerate and bands of pyrites	12	0	685	0	
Sandstone [incoherent sandstone]	4	0	697	0	
Argillaceous limestone	14	0	701	0	
Sand [incoherent sandstone?] ...	10	0	715	0	
Argillaceous limestone	5	0	725	0	
Hard grey sandstone	3	0	730	0	
Red shale	2	0	733	0	
Sandstone, with bands of shale...	5	6	735	0	
Red shale	3	6	740	6	
Sandstone with bands of shale and conglomerate intermixed...	219	0	744	0	
Shale	4	0	963	0	
Sandstone	15	0	967	0	
Shale	2	0	782	0	
Hard grey sandstone with bands of shale	27	0	984	0	
Red shale	12	0	1,011	0	
Sandstone with thin bands of shale	44	0	1,023	0	
Red shale	9	0	1,067	0	
Sandstone and shale	4	0	1,076	0	
Conglomerate	11	0	1,080	0	
Sandstone with bands of shale and pyrites	76	0	1,091	0	
Shale	17	0	1,167	0	
Sandstones and thin shales ...	75	0	1,184	0	
Conglomerate	10	0	1,259	0	
Alternations of sandstone and shale	177	0	1,269	0	
Calcareous shale and agillaceous limestone	28	0	1,446	0	
Sandstone	52	6	1,474	0	
Siliceous crystalline limstone ...	0	9	1,526	6	
Coarse sandstone	4	3	1,527	3	
Total	1,531	6	1,531	6	

The whole country along the coast from Geraldton to Dongara is made up of the Coastal Limestone series, which rise in the form of sand plains to an altitude of about 500ft. These beds effectually conceal the underlying rocks, and at the few places where these are seen a low dip to the West is observable. From Geraldton the Coastal Limestone series widens out and covers an extensive area of country, which attains its maximum width on the Irwin River.

A Government bore was put down, near the mouth of the Irwin River at Dongara, to a depth of 2,111ft. Particulars in connection with this are given in Chapter IX.

A bore was put down at Onslow to a depth of about 1,729 feet, but it was not very successful, hence its abandonment. The particulars in connection with this bore are as follows:—

Onslow Bore.

Nature of Strata.	Thickness.		Depth.		Remarks.
	ft.	in.	ft.	in.	
Sand	30	0	...		Water struck at 1,015 feet, which trickled over the surface at the rate of 20 to 30 gallons per diem. At 1,717 feet yields 120 gallons per diem. Hydrostatic pressure, 10·82lbs. per square inch. Hydrostatic head, 25 feet above surface. Water salt.
Limestone	183	10	30	0	
Calcareous shale	30	11	213	10	
Grey shale	361	8	244	9	
Grey dolomite	34	10	606	5	
Grey shale	731	3	641	3	
Dark grey marl	82	6	1,372	6	
Sandstone	0	10	1,455	0	
Clay (? shale)	21	2	1,455	10	
Dark grey marl	66	0	1,477	0	
Clay (? shale)	3	1	1,543	0	
"Hard stone" (?)...	0	8	1,546	1	
Sandstone	9	6	1,546	9	
"Hard rock" (?)	0	3	1,556	3	
Shale	6	2	1,556	6	
Calcareous shale	5	4	1,562	8	
Shale	70	8	1,568	0	
Black argillaceous limestone ...	0	4	1,638	8	
Shell marl	53	1	1,639	0	
Shale	4	0	1,692	1	
Black argillaceous limestone ...	2	0	1,696	1	
Shale	14	5	1,698	1	
Clay and sand	8	6	1,712	6	
Basalt	2	0	1,721	0	
Marl	5	10	1,723	0	
Total	1,728	10	1,728	10	

In addition to the above, numerous shallow bores have been put down in the Eastern Agricultural Districts. The wells put down have derived their supplies from those superficial deposits which are surcharged with water, and which cover an extensive area of country. The supply yielded by these wells is directly dependent upon the saturation of the ground immediately surrounding them, and is in no sense artesian. Full details in connection with these wells have already been published,* and need not be further referred to.

* A. Gibb Maitland. Proposed boring for artesian water in the Eastern Agricultural Districts. Annual Progress Report of the Geological Survey for the Year 1898. Perth: By Authority, 1899; pp. 22-29.

from a mineral point of view :—

*Chemical Analyses of Water from Artesian Wells.**

Analyst: E. A. Mann.

No. of Analysis.	Locality of Bore.	Grains per Gallon.									Reaction.	Degree of Hardness.	Grains per 100,000.				
		Total Solids.	Alumina and Iron.	Carbonates.		Chlorides.		Total Chlorine.	Sulphates.				Ammonia.		Oxygen absorbed.		Nitrogen Nitrates.
				Calcium. $Ca\,CO_3$	Magnesium $Mg\,CO_3$	Sodium. NaCl	Magnesium $Mg\,Cl_2$		Calcium. $Ca\,SO_4$	Magnesium $Mg\,SO_4$			Free.	Albuminoid	In 15″	In 4 hours.	
1	Geraldton Station Yard ...	12·77	...	9·8	1·2	907·2	173·1	122·5	61·9	...	...	...	...	...	...	...	1·3
2	Dongara	...	...	...	...	1008·5	...	607 6	...	...	...	...	...	...	...	...	...
3	Do.	...	...	...	...	602·43	...	365·1	...	...	...	...	...	...	...	...	...
4	Water Hall Estate... ...	51·24	...	...	...	...	...	...	...	...	...	7°	·005	·003	·047	·063	...
5	Municipal Bore, Guildford	36·12	...	...	...	14·5	...	...	...	...	...	7°	·007	·007	...	...	...
6	Do. do. ...	93·6	1·55	5·95	...	73·88	...	...	888·5	...	Alk.	11·5°	·014	·003	·01	...	·014
7	Do. do. ...	87·22	...	...	...	...	...	39·2	...	...	...	12°	·0145	·0085	...	...	...
8	Perth Cricket Asn. Ground	...	...	...	...	...	..	...	...	...	...	...	·02	·001	...	·043	·024
9	Leederville Asn. Ground ...	39·9	...	...	...	...	...	19·4	...	...	...	3°	·017	·001	...	·07	·033
10	Perth Station Yard ...	34·72	...	...	..	...	...	15·12	...	...	...	7·5°	·04	·011	...	...	...
11	Do.	44·34	°/₀896	8·568	...	32·67	...	...	2·198	...	...	...	·02	·0015	...	·019	·027
12	Do.	...	...	...	...	...	...	...	...	...	...	...	·015	·002	...	...	...
13	Subiaco	...	...	...	...	...	...	...	...	...	...	...	·06	·046	...	·27	...
14	Perth, Wellington St. Bore	...	...	...	...	...	...	...	...	...	...	...	·013	·008	...	...	...
15	Do. do. ...	...	...	...	...	...	...	...	...	...	...	...	·018	·006	...	...	...
16	Do. do. ...	34·27	2·06	6·244	...	23·436	...	...	2·268	...	...	...	·0185	·0025	...	·015	·059
17	South Perth	16·1	...	...	...	...	...	6·02	...	...	...	2·5°	...	...	...	...	...
18	Do.	66·08	...	...	...	...	...	30·1	...	...	...	4°	·03	·002	...	·064	·02
19	Melville Water Park Estate	...	...	...	...	...	...	...	...	...	...	...	·062	·005	...	...	...
20	Collie Bore (? 2 or 3) ...	16·1	...	...	...	...	...	...	...	...	...	...	·009	·0125	·0132	·0132	...
21	Do. ,, ,, ...	21·07	...	...	...	...	...	...	...	...	...	...	·0125	·011	·012	·0512	...
22	Do. ,, ,, ...	12·04	...	...	...	...	...	...	...	...	...	...	·0135	·0155	·012	·01807	...
23	Do. ,, ,, ...	20·44	...	...	...	...	...	...	...	...	...	...	·0285	·0125	·015	·0361	...
24	Bunbury (2) Bore	21·42	8·19	3·587	...	21·162	...	...	...	1·18	...	...	...	...	...	...	...

* Annual Report of the Department of Public Works for the Year 1898-99. Perth : By Authority, 1899 ; p. 52.

CHAPTER XII.

CENSUS OF MINERALS OF WESTERN AUSTRALIA.

By E. S. Simpson, B.E., F.C.S., Mineralogist and Assayer.

The following list of minerals has been compiled from the various reports and other documents in the library of the Geological Survey at Perth, as well as from personal observation. Such a small area of the Colony has up to the present been examined systematically from a geological stand-point, that the census is necessarily very incomplete, but it will illustrate the wide distribution of useful minerals in Western Australia, and form the basis for a more complete catalogue as fresh discoveries are chronicled.

The commoner rock-forming minerals such as quartz, felspars, micas, amphibole, etc., have been omitted, except where their occurrence is of marked interest.

Most of the localities mentioned in this list are to be found on the 60-Mile map (dated 1/12/97) published by the Mines Department. In order that they may be the more readily identified the goldfield or division of the Colony in which they are situated is always indicated, the following abbreviations being employed :—

K.—Kimberley G.F
Pil.—Pilbarra G.F.
W.P.—West Pilbarra G.F.
Ash.—Ashburton G.F.
Gas.—Gascoyne G.F.
P.H.—Peak Hill G.F.
M.—Murchison G.F.
Yal.—Yalgoo G.F.
E.M.—East Murchison G.F.
M.M.—Mount Margaret G.F.
N.C.—North Coolgardie G.F.
Ygn.—Yilgarn G.F.
C.—Coolgardie G.F.
B.A.—Broad Arrow G.F.
E.C.—East Coolgardie G.F.
N.E.C.—North-East Coolgardie G.F.
Dun.—Dundas G.F.

Localities Outside Goldfields.

N.E. —East of 121° East and North of 28° South.
N.W.—West of 121° East and North of 28° South.
S.W.—West of 121° East and South of 28° South.
S.E. —East of 121° East and South of 28° South.

Amalgam (*Alloy of gold and mercury*).—Boulder, E.C.

Anglesite (*Sulphate of lead*).—Gorge Creek, Ash.

Aragonite (*Carbonate of calcium*).—Kanowna, N.E.C.

Arsenopyrite (*Sulpharsenide of iron*).—Ruby Creek, K.; Niagara, N.C.; Smithfield, B.A.; Coolgardie, C.; Paddington, B.A.

Asbestos (*Hydrated silicate af magnesium*).—Jarman Island, W.P.; Tambourah (70 miles N. of), Pil.; Menzies, N.C.; Hannan's Lake, E.C.; Mt. Magnet, M.; Upper Henry River, N.W.; Feysville, E.C.

Asbolite (*Hydrous oxide of manganese and cobalt*).—Kanowna, N.E.C. Norseman, Dun.

Atacamite (*Hydrated oxychloride of copper*).—Peninsula, Dun.

Azurite (*Hydrated carbonate of copper*).—Yalgoo, Yal.; Sir Samuel, E.M.; Northampton, S.W.; Arrino, S.W.; Mt. Misery, S.W.; Ravensthorpe Ranges, S.W.; Coolgardie, C.; Kurawa, B.A.; Narra Tarra, S.W.; Whim Creek, W.P.; Leonora, M.M.

Barite (*Sulphate of barium*).—Northampton, S.W.; Denmark, S.W.

Bismite (*Oxide of bismuth*).—Yalgoo, Yal.

Bismuth (*Native metal*).—Burbanks, C.; Lawlers, E.M.; Dundas, Dun.

Bismuthinite (*Sulphide of bismuth*).—Yalgoo, Yal.

Bismutite (*Hydrated carbonate of bismuth*).—Lawlers, E.M.; Burbanks, C.

Bitumen (*Oxygenated mixture of hydro-carbons*).—Horseshoe, P.H.

Blende (*Sulphide of zinc*).—Northampton, S.W.; Geraldine, N.W.; Coolgardie, C.; Lawlers, E.M.; Yandicoogina, Pil.; Cardup, S.W.

Bornite (*Sulphide of copper and iron*).—Wyman's, Pil.; Gabanintha, M.

Bournonite (*Sulphantimonite of copper and lead*).—Wiluna, E.M.; Boulder, E.C.

Breunerite (*Carbonate of magnesium and iron*).—Bardoc, B.A.; Hannan's Lake, E.C.

Calaverite (*Telluride of gold*).—Boulder, E.C.

Calcite (*Carbonate of Calcium*).—Hall's Creek, K.; Mary River, K.; Panton River, K.; Coolgardie, C.; Boulder, E.C.; Hannan's Lake, E.C.; Paddington, B.A.; Napier Range, K.; Oscar Range, K.; Geikie Range, K.; Mt. Pierre, K.; Devil's Pass, K.; Fremantle, S.W.; and elsewhere along the West Coast; Red Hill, C.; Moore River, S.W.; Hill River, S.W.; Quindalup, S.W.; etc.

Cassiterite (*Oxide of tin*).—Head of the Bow River, K.; Head of the Lennard River, N.E.; Western Shaw, Pil.; Brockman's Soak, Pil.; Greenbushes, S.W.

Cerargyrite (*Chloride of silver*).—Red Hill, C.

Cerussite (*Carbonate of lead*).—Mt. DeCourcy (10 miles S.E. of), N.W.; Gorge Creek, Ash.; Geraldine, N.W.; Northampton, S.W.; Roebourne, W.P.

Chalcosite (*Sulphide of copper.*)—Northampton, S.W.

Chalcopyrite (*Sulphide of copper and iron*).—Hall's Creek, K.; Panton River, K.; Ruby Creek, K.; Tambourah, Pil.; Wyman's Pil.; Yandicoogina, Pil.; 20-Mile, Sandy Creek, Pil.; Whim Creek, W.P.; Croydon, W.P.; Hong-kong, W.P.; Roebourne, W.P.; Red Hill, N.W.; Wongan Hills, S.W.; Northampton, S.W.; Geraldine, N.W.; Coolgardie, C.; Sir Samuel, E.M.; Earlstoun, M.M.; Knutsford, Ygn.

Chrysocolla (*Hydrated silicate of copper*).—Red Hill, N.W.; Mt. Misery, S.W.; Sir Samuel, E.M.; Ravensthorpe Ranges, S.W.

Coal.—Collie, S.W.; Fly Brook, S.W.; Upper Irwin River, S.W.; Dongara, S.W.; Dardanup, S.W.; Coolgardie, C.

Coloradoite (*Telluride of mercury*).—Boulder, E.C.

Copper (*Native metal*).—Mount Scratch, S.W.; Roebourne, W.P.; Geraldine, N.W.; Northampton, S.W.; Sir Samuel, E.M.; Coolgardie, C.

Covellite (*Sulphide of copper*).—Northampton, S.W.; Arrow Lake, B.A.; Kanowna, N.E.C.; Whim Creek. W.P.

Crocoisite (*Chromate of lead*).—Menzies, N.C.

Cuprite (*Oxide of copper*).—Whim Creek, W.P.; Tambourah, Pil.; Red Hill, N.W.; Geraldine, N.W.; Northampton, S.W.; Mount Misery, S.W.

Cyanite (*Silicate of aluminium*).—Londonderry, C.

Diamond (*Carbon*).—Nullagine, Pil.

Dolomite (*Carbonate of calcium and magnesium*).—Onslow, N.W.; Coolgardie, C.; Kanowna, N.E.C.; Hannan's Lake, E.C.; Millie Soak, M.

Epidote (*Silicate of calcium, aluminium, and iron*).—Mary River, K.; Ramsay Range, near Margaret River, K.; Broad Arrow, B.A.; Mundaring, S.W.; Donnybrook, S.W.; Southern Cross, Ygn.

Epsomite (*Hydrous sulphate of magnesium*).—Lake, eight miles North of Kanowna, N.E.C.; and most other salt lakes of the Southern interior.

Galena (*Sulphide of lead*).—Hall's Creek, K.; Mt. Dockerell, K.; Tambourah, Pil.; Warrawoona, Pil.; Hardey River, Ash.; Gorge Creek, Ash; Mt. Edith, N.W.; Mt. DeCourcy, N.W.; Horseshoe, P.H.; Geraldine, N.W.; Northampton, S.W.; Oakagee, S.W.; Narra Tarra, S.W.; Earlstoun, M.M.; Cardup, S.W.; Nannine, M.; Southern Cross, Ygn.; Menzies, N.C.; Coolgardie, C.; Brockman's, K.; Panton River, K.; Ruby Creek, K.; Roebourne, W.P.

Garnet (*Almandine, Silicate of Iron, and Aluminium*).—Upper Lennard River, K.; Albany, S.W.; Northampton, S.W.; Donnybrook, S.W.; Greenbushes, S.W.

Gold (*Native metal*)—

A.—Kimberley G.F.:—Hall's Creek, Brockman's, Mt. Dockerell, Ruby Creek, Panton River, Mt. Coghlan, Mt. Bradley.

B.—Pilbarra G.F.:—Marble Bar, Nullagine, Elsie Creek, Cooke's Creek, Mosquito Creek, Shark's Gully, Yandicoogina, Sandy Creek, Warrawoona, Bamboo Creek, Talga Talga, Tambourah, Shaw River, Head of Turner River.

C.—West Pilbarra G.F.:—Egina, Hong Kong, Pilbarra, Mallina, Towranna, Croydon, Roebourne, Nichol, Lower Nichol.

D.—Ashburton G.F.:—Gorge Creek, Top Camp, Mt. Mortimer, Hardey River, Tannaradgie, Dead Finish, Soldier's Secret.

E.—Gascoyne G.F.:—Bangemall, El Dorado.

F.—Peak Hill G.F.:—Peak Hill, Horseshoe, Mt. Maitland.

G.—Murchison G.F.:—Cue, Day Dawn, Mainland, Island Lake Austin, Gabanintha, Burnakura, Nannine, Meekatharra, Abbott's, Garden Gully, Munara, Mt. Magnet, Cuddingwarra, Boogardie, Lennonville, Weld Range, Quin's, Tuckanarra, Webb's, Mulleta.

H.—East Murchison G.F.:—Lawlers, Sir Samuel, Wiluna, Barlow's, Abbott's, Darlôt, Ogilvie's, Kathleen Valley, Anderson's, Wilson's.

I.—Mt. Margaret G.F.:—Mt. Margaret, Leonora, Randwick, Westralia Mt. Morgan, Euro, Golden Hill, Jubilee, Lancefield, Murrin Murrin, Laverton, Earlstoun, Mt. Weld, Korong, Redcastle. Benalla, Mt. Ross, Kurrajong, Mt. Davis, Crawford, Mt. Vardon, Bates, Mt. Amy, Hawk's Nest, Stirling, King of the Hills, Mt. George, Pride of the North, Mertondale, Australian Peer, Malcolm, Mt. Malcolm, Cardinia, Mt. Abednego, Waverley.

J.—Yalgoo G.F.:—Yalgoo, Bilberatha, Noongal, Pinyalling, Lang's, Bates, Gullewa, Ederga, Carlaminda, Cumberland, Woodley's, Rothesay, Mt. Singleton, Nancarrong, Wadgingarra, Mugga Mugga.

K.—North Coolgardie G.F.:—Menzies, Goongarrie, Niagara, Griffithston, Mt. Ida, Mulline, Ularring, Yerilla, Mt. Catherine, Pendennie, Eucalyptus, Yilgangi, Edjudina, Linden, Pennyweight Point, Pyke's Hollow, Tampa, Armidale, Callion, Mt. Remarkable.

L.—Yilgarn G. F.:—Mt. Jackson, Knutsford, Southern Cross, Parker's Range, Jacolettis, Yellowdine, Hope's Hill.

M.—Coolgardie G.F.:—Coolgardie, Burbanks, Londonderry, Bullabulling, Gibralta, Gnarlbine, Red Hill, Widgiemooltha, Bonnievale, Kundanna, Barwon, Kunanalling, Kintore, London, Dunn's, Dunnsville, Carbine, Balgarrie, Grant's, Mascotte, Cashman's, Carnage, Christmas Reef, Siberia.

N.—Broad Arrow G.F.:—Bardoc, Broad Arrow, Paddington, Windanya, Black Flag, Dixie.

O.—East Coolgardie G.F.:—Kalgoorlie, Boulder, Feysville, Block 45, Binduli, Boorara, Block 48, Block 50.

P.—North-East Coolgardie G.F.:—Kanowna, Kurnalpi, Bulong, Ballagundi, Mt. Monger, Taurus, Garribaldi, Wellington, Vosperton, Lindsay's, Mulgarrie, Mt. Eba.

Q.—Dundas G.F.:—Dundas, Norseman, Peninsula, Mt. Kirk, Mt. Deans, Buldania.

R.—Donnybrook G.F.:—Donnybrook.

S.—Localities outside Proclaimed Goldfields:—Ravensthorpe Ranges, S.W.; Greenbushes, S.W.; Blackboy Hill, S.W.; Peterwangy, S.W; Wongan Hills, S.W.; Kendinup, S.W.; Bindoon, S.W.

Graphite (*Carbon*).—Cue, M.; Northampton, S.W.; Kendinup, S.W.; Head of Donnelly River, S.W.; Coolgardie, C.; Kalgoorlie, E.C.; York, S.W.

Guano (*Mixture of Phosphates of Calcium with Carbonates, etc.*).—Abrolhos Islands, S.W.; Lacepede Islands, N.W.; Monte Bello Islands, N.W.

Gypsum (*Hydrated sulphate of calcium*).—Lake Cowan, Dun.; Lake, eight miles North of Kanowna, N.E.C.; most other salt lakes in the Southern interior; Coolgardie, C.; Upper Irwin River, S.W.; Oscar Range, K.; Onslow, N.W.; Kalgoorlie, E.C.; Island Lake Austin, M.; Menzies, N.C.

Hematite (*Oxide of iron*).—Mt. Hardman, K.; Mt. Marmion, K.; Marble Bar, Pil.; Mt. Hale, P.H.; Peak Hill, P.H.; Mt. Gould, P.H.; Mount No Name, P.H.; Weld Ranges, M.; Montagu Range, E.M.; Mt. Narryer, N.W.; Goomalling, S.W.; Greenhills, S.W.; Cookernup, S.W.; Munara, M.; Mt. Jackson, Ygn.; Boulder, E.C.; Bardoc, B.A.; Mulgarrie, N.E.C.; Bridgetown, S.W.; Red Hill, N.W.

Halite (*Common salt, chloride of sodium*).—All the salt lakes in the Southern interior; Rottnest Island, S.W.

Halloysite (*Hydrated silicate of aluminium*).—Cue, M.

Hausmannite (*Oxide of manganese*).—Broad Arrow, B.A.

Hypersthene (*Silicate of iron and magnesium*).—Margaret River, K.; Greenhills, S.W.; Bardoc, B.A.

Ilmenite (*Oxide of iron and titanium*).—In all the more basic igneous rocks of the Colony, as well as in most river sands. Largely developed at Greenbushes, S.W.; Mt. Barker, S.W.; Fitzroy River, K.

Iron (*Native metal*).—Meteorites consisting largely of metallic iron have been found at Wogerlin Spring, Youndegin District, S.W.; Mooranopin, S.W.; Hammersley Range, N.W.; Ballinoo, M.

Jamesonite (*Sulphantimonite of lead*).—Mt. DeCourcy, N.W.

Kalgoorlite (*Telluride of gold, silver, and mercury*).—Boulder, E.C.

Kaolin (*Hydrated silicate of aluminium*).—Very pure at Menzies, N.C.; Kanowna, N.E.C.; Collie, S.W.; and elsewhere.

Lepidolite (*Fluosilicate of aluminium, potassium, and lithium*).—Londonderry, C.

Limonite (*Hydrated oxide of iron*).—Found everywhere throughout the Colony. Some more important localities are:—Rough Range, K.; East of Mt. Elder Range, K.; Poondanah, Pil.; Gibson's Desert, N.E.; Peak Hill, P.H.; Clackline, S.W.; Greenhills, S.W.; Greenbushes, S.W.; Coolgardie, C.; Kalgoorlie, E.C.; Bardoc, B.A.; etc.

Lollingite (*Arsenide of iron*).—Coolgardie, C.; Boulder, E.C.

Magnesite (*Carbonate of magnesium*).—Coolgardie, C.; Hannan's Lake, E.C.; Kanowna, N.E.C.; Bardoc, B.A.; Menzies, N.C.

Magnetite (*Oxide of iron*).—Lodestone Hill, K.; Paradise, S.W.; Collie River, S.W.; Darling Ranges, near Pinjarrah, S.W.; Katanning, S.W.

Malachite (*Hydrated carbonate of copper*).—Devil's Pass, N.E.; Oscar Range, near Brooking Creek, N.E.; Geikie Range, N.E.; Mt. Pierre N.E.; Mueller Range, near Margaret River, K.; Hall's Creek, K.; Panton River, K.; Whim Creek, W.P.; Tambourah, Pil.; Wyman's, Pil.; Red Hill, N.W.; Roebourne, W.P.; Gorge Creek, Ash.; Horseshoe, P.H.; Mt. Gould, P.H.; Geraldine, N.W.; Yalgoo, Yal.; Northampton, S.W.; Arrino, S.W.; Mt. Misery, S.W.; Wongan Hills, S.W.; Boorara, E.C.; Coolgardie, C.; Broad Arrow, B.A.; Sir Samuel, E.M.; Mulline, N.C.; Narra Tarra, S.W.; Phillip's River, near East Mt. Barren, S.W.; Middle Mt. Barren, S.W.; Leonora, M.M.; Goongarrie, N.C.

Molybdenite (*Sulphide of molybdenum*).—Clackline, S.W.; Coolgardie, C.; Southern Cross, Ygn.; Buldania, Dun.

Molybdite (*Oxide of molybdenum*).—Clackline, S.W.

Muscovite (*Silicate of aluminium and potash*).—Occurs in most granites and metamorphic rocks throughout the Colony. Developed on a large scale at Tambourah, Pil.; Londonderry, C.; Wagin, S.W.; Northampton, S.W.; Mullayup, S.W.; Pyramid Hill, N.W.

Opal (*Hydrous silica*).—1. Common opal.—Mooran, P.H.; Hannan's Lake, E.C.; Jerramungup, S.W. 2. Hyalite.—Coolgardie, C.; Bardoc, B.A.; Mt. Magnet, M. 3. Siliceous sinter.—Northampton, S.W.; Molygoa Well, P.H.; Bubba Ngundi Creek, M.; Burbanks, C.; Hannan's Lake, E.C.

Orthoclase (*Silicate of aluminium and potassium*).—Occurs in the granites, etc., throughout the Colony. In large crystals at Northampton, S.W.; Albany, S.W.; Collie Quarry, S.W.; Londonderry, C.

Psilomelane (*Hydrated oxide of manganese*).—Coolgardie, C.

Pyrites (*Sulphide of iron*).—Occurs plentifully in almost every district in the Colony.

Pyrolusite (*Oxide of manganese*).—Mt. Hardman, K.; El Dorado, Gas.; Tooncoonarlagee, Pil.; Wiluna, E.M.; York, S.W.

Pyromorphite (*Chlorophosphate of lead*).—Narra Tarra, S.W.; Northampton, S.W.; Geraldine, N.W.

Pyrrhotite (*Sulphide of iron*).—Southern Cross, Ygn.; Coolgardie, C.; Burbanks, C.; Knutsford, Ygn.; Moora, S.W.

Quartz (*Silica*).—1. Ordinary quartz.—Occurs in every district of the Colony as a constituent of rocks or veins. Good crystals are found at Burbanks, C.; Mulgarrie, N.E.C. 2. Chalcedony.—Widely distributed amongst the older rocks in the form of jasper "bars," as at Coongan River, Pil.; Weld Ranges, M.; Hannan's Lake, E.C. Important localities for other varieties of chalcedony are Lubbock Range, K.; Mt. Elder Range, K.; Tooncoonarlagee, Pil.; Hannan's Lake. E.C.; Londonderry, C.

Roscoelite (*Silicate of aluminium, vanadium, etc.*).—Boulder, E.C.

Scheelite (*Tungstate of calcium*).—Southern Cross, Ygn.; Coolgardie, C.

Serpentine (*Hydrated silicate of magnesium*).—Occurs in many districts as a product of decomposition of amphibolites and other basic rocks. Important localities are Mount Dick, S.W.; Coolgardie, C.; Hannan's Lake, E.C.; *vide* "Asbestos."

Siderite (*Carbonate of iron*).—Cue, M.; Menzies, N.C.; Kanowna, N.E.C.; Kalgoorlie, E.C.; Hannan's Lake, E.C.; Vosperton. N.E.C.; Burbanks, C.

Silver (*Native metal*).—Nannine, M.

Sphene (*Titano-silicate of calcium*).—Coolgardie, C.

Stibiotantalite (*Tantalo-niobate of antimony*).—Greenbushes, S.W.

Stibnite (*Sulphide of antimony*).—Mallina, W.P.; Peewah. W.P.

Sulphur (*Native element*).—Peak Hill, P.H.

Sylvanite (*Telluride of gold and silver*).—Boulder, E.C. (Teste, Frenzel, Min. Petr. Mitth., 17, 288, 1897).

Talc (*Hydrated silicate of magnesium*).—Lennonville, M.; Coolgardie, C.; Cue, M.

Tenorite (*Oxide of copper*).—Croydon, W.P.; Hong Kong, W.P.; Red Hill, N.W.; Arrino, S.W.

Tin (*Native metal*).—Greenbushes, S.W.

Tourmaline (*Silicate of boron, aluminium, etc.*).—Lennard River at junction with Richenda River, K.; Mt. Phillip, K.; Brockman's Soak, Pil.; Northampton, S.W.; Bowes, S.W.; Greenbushes, S.W.; Niagara, N.C.; Pinyalling, Yal.; Widgiemooltha, C.; Kalgoorlie, E.C.

Turgite (*Hydrated oxide of iron*).—Greenbushes, W.A.

Vanadinite (*Chlorovanadate of lead.*)—Pinyalling, Yal.; Coolgardie, C.

Wolfram (*Tungstate of iron*).—Roebourne, W.P.

Zircon (*Silicate of zirconium*).—Greenbushes, S.W.

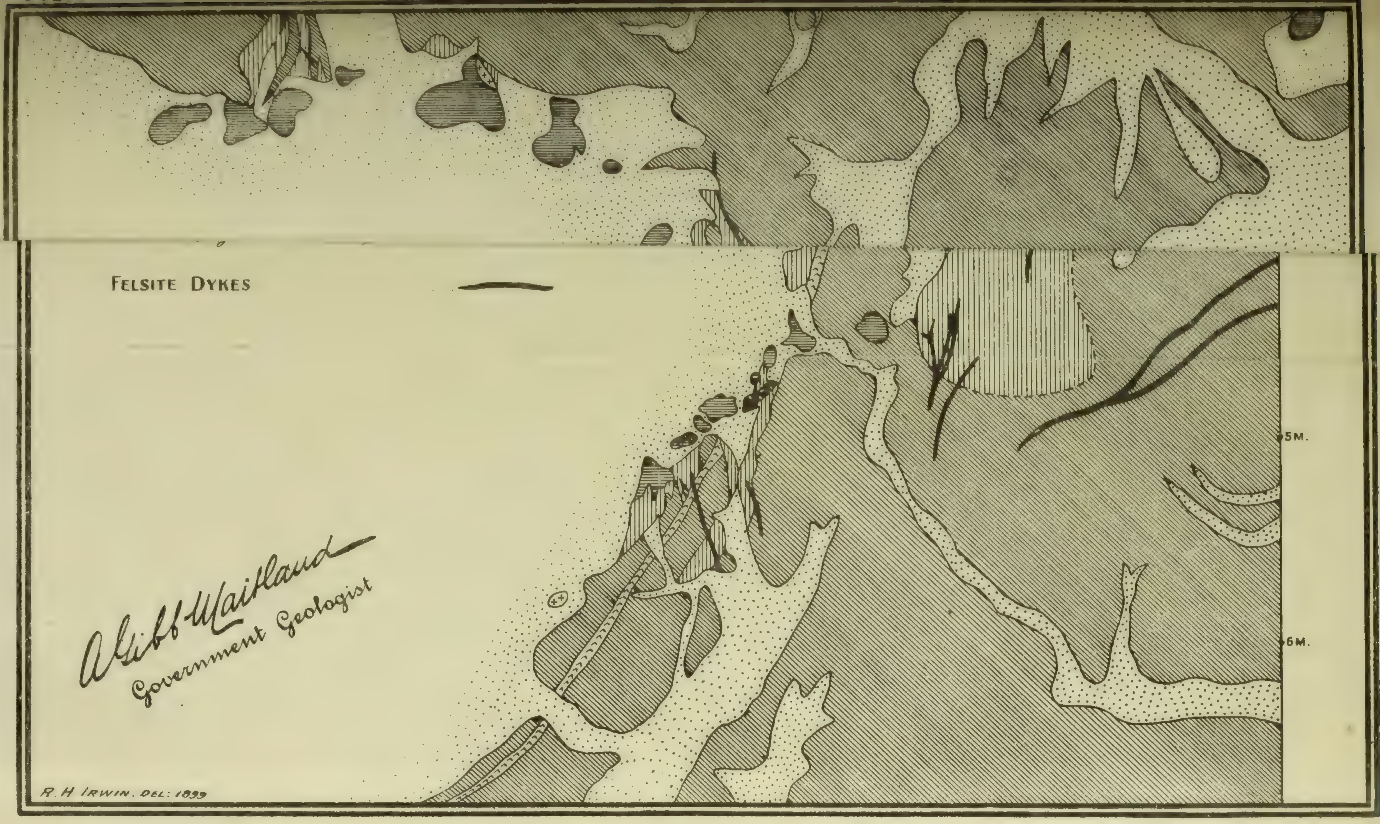
Appendix A.

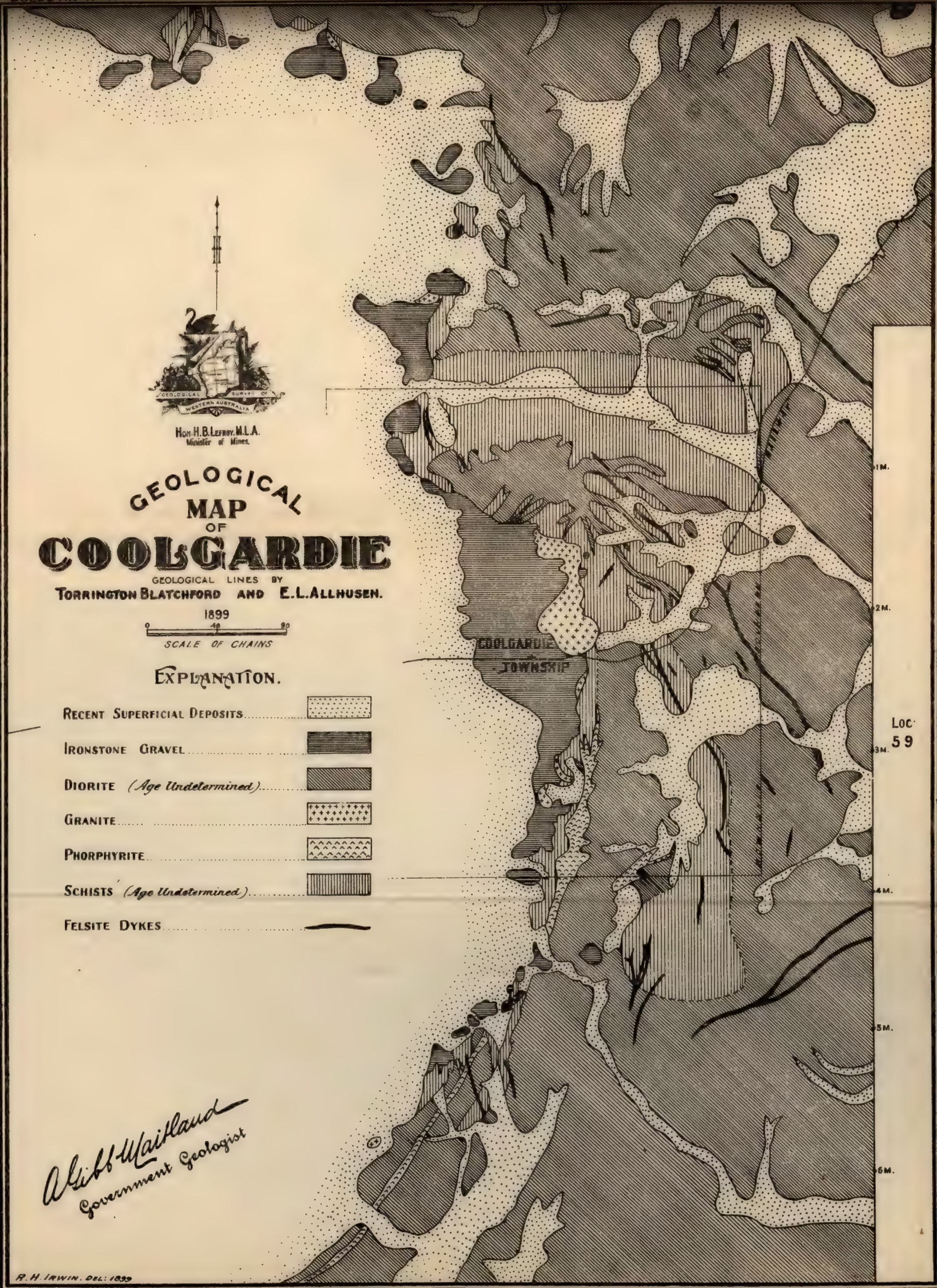
General Return showing the Value of the Mineral Products of the Colony up to the end of 1899.

The aggregate value of the mineral products of the Colony up to the close of 1899 is estimated to be £17,490,446, made up as follows:—

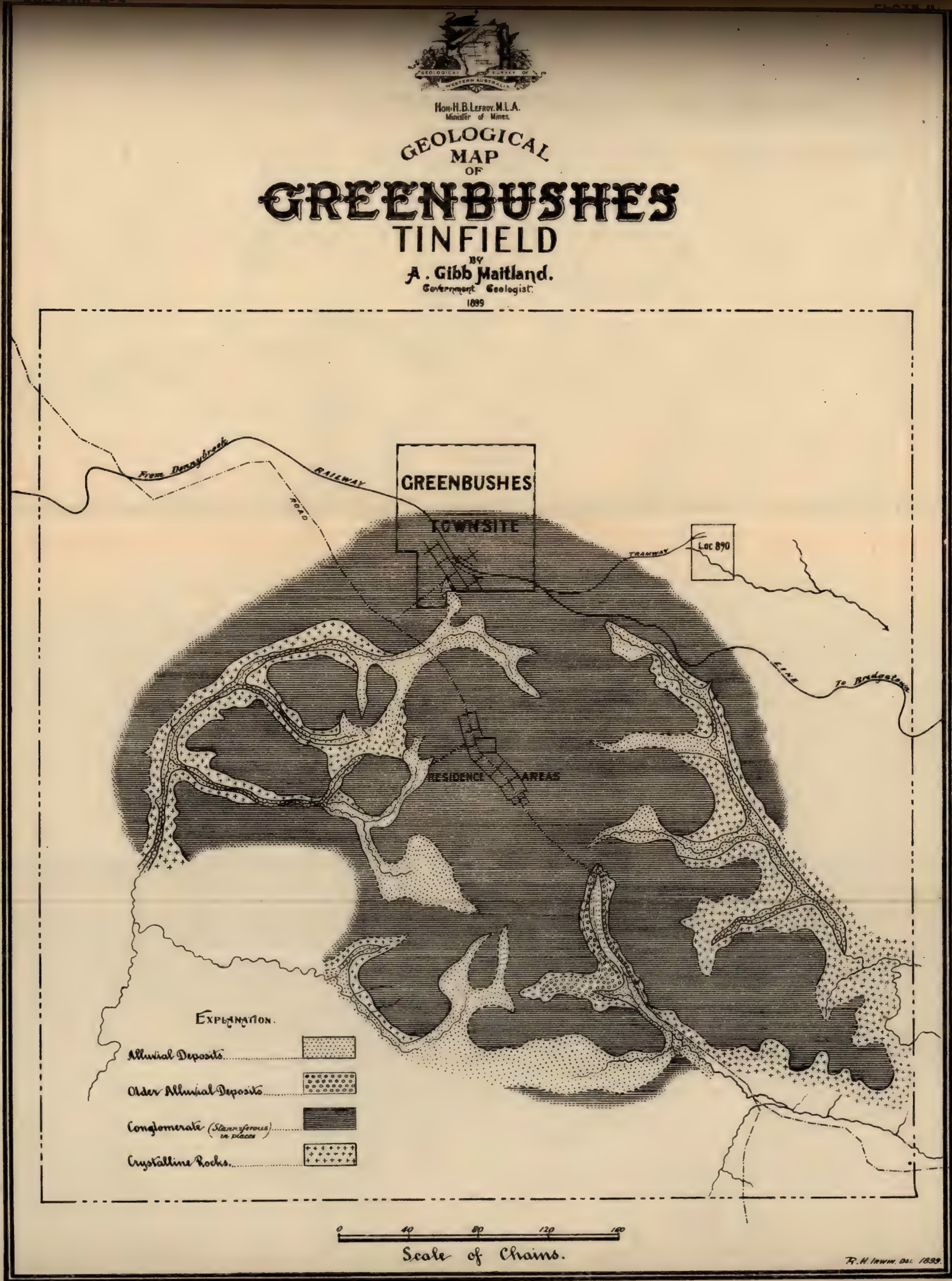
MINERALS.	ESTIMATED VALUE. £	s.	d.	REMARKS.
Asbestos	1	0	0*	*Customs Records.
Coal	27,712	0	0	
Copper	208,297	10	0*	
Gold	16,446,569	2	8*†	*†Includes the value of the gold coined at the Mint.
Guano	318,488	15	0	
Iron (flux)	8,939	0	0	
Lead	377,820	5	0*‡	‡Includes pig lead.
Limestone (flux) ...	2,838	0	0	
Mica	291	0	0*	
Tin	99,490	0	0*	
Total ...	17,490,446	12	8	

By Authority: Richard Pether, Government Printer, Perth.

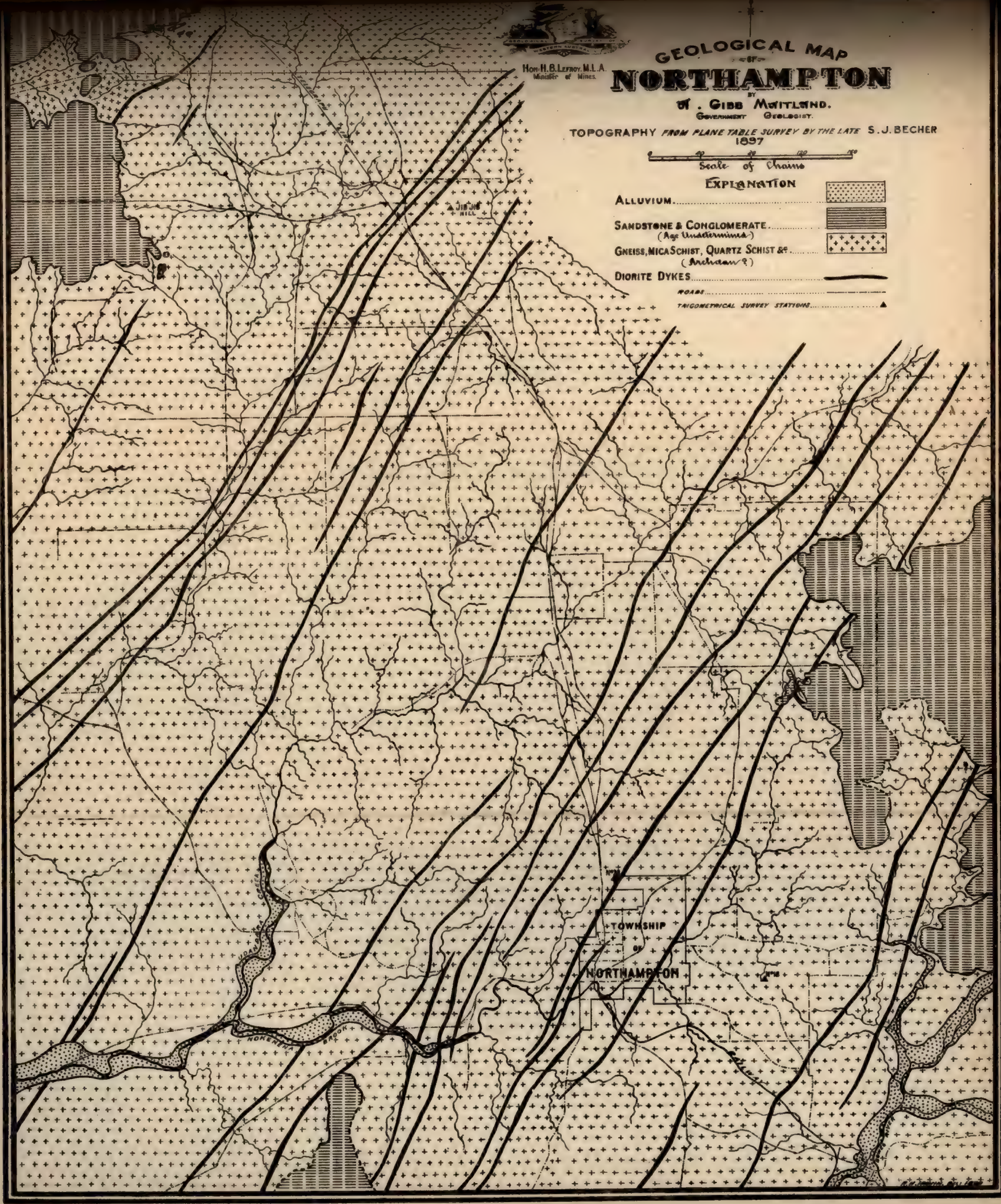

FELSITE DYKES
5M.
6M.
A Gibb Maitland
Government Geologist
R. H. IRWIN. DEL: 1899

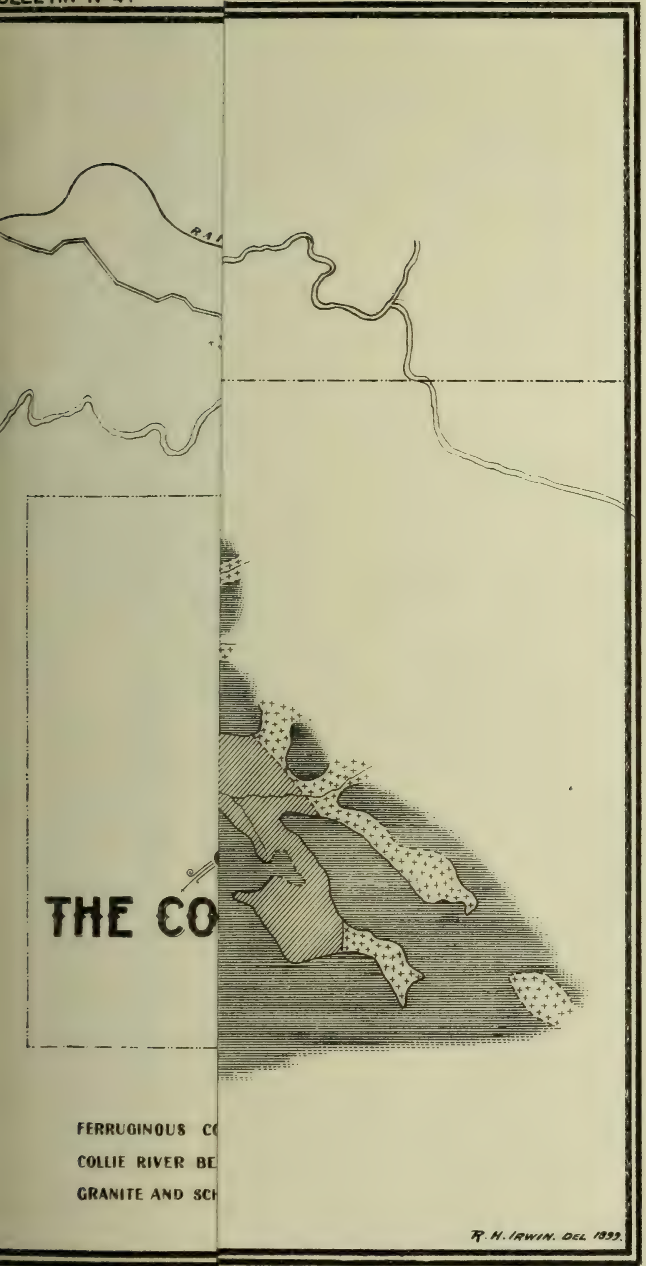

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
HON. H. B. LEFROY, M.L.A.
Minister of Mines.
GEOLOGICAL MAP OF COOLGARDIE
GEOLOGICAL LINES BY
TORRINGTON BLATCHFORD AND E. L. ALLHUSEN.
1899
0 40 80
SCALE OF CHAINS
EXPLANATION.
RECENT SUPERFICIAL DEPOSITS
IRONSTONE GRAVEL
DIORITE (Age Undetermined)
GRANITE
PHORPHYRITE
SCHISTS (Age Undetermined)
FELSITE DYKES
COOLGARDIE TOWNSHIP
LOC 59
1M.
2M.
3M.
4M.
5M.
6M.
A. Gibb Maitland
Government Geologist
R. H. IRWIN. DEL: 1899

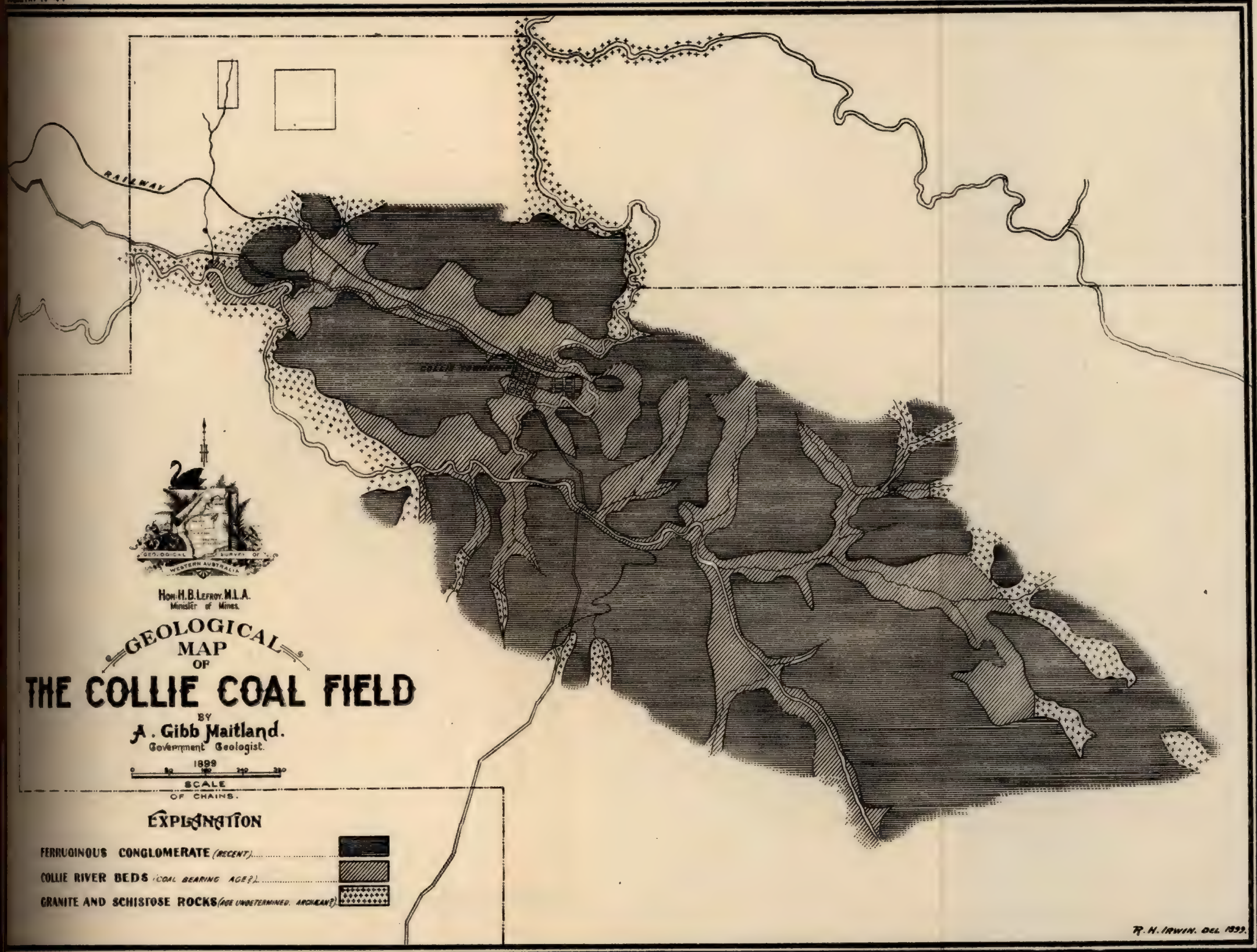

GEOLOGICAL SURVEY OF
WESTERN AUSTRALIA
HON: H. B. LEFROY. M.L.A.
Minister of Mines.
GEOLOGICA
EXPLANATION.
Alluvial Deposits
Older Alluvial Deposits
Conglomerate (Stanniferous in places)
Crystalline Rocks
0
40
80
120
160
Scale of Chains.
F. H Irwin Del. 1899.

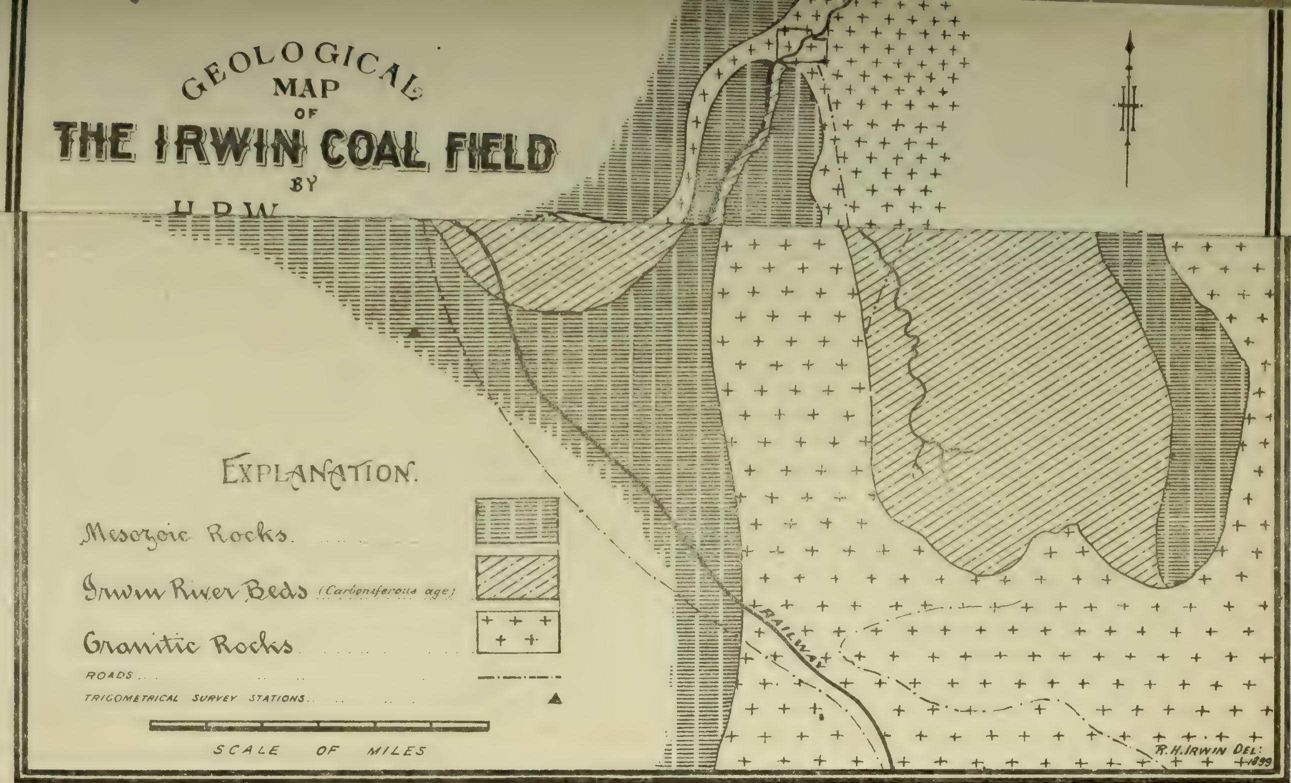

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
Hon. H.B. Lefroy, M.L.A.
Minister of Mines.
GEOLOGICAL MAP OF
GREENBUSHES
TINFIELD
BY
A. Gibb Maitland.
Government Geologist.
1899
From Donnybrook
RAILWAY
ROAD
GREENBUSHES
TOWNSITE
TRAMWAY
Loc 890
LINE
To Bridgetown
RESIDENCE
AREAS
Explanation.
Alluvial Deposits
Older Alluvial Deposits
Conglomerate (Stanniferous in places)
Crystalline Rocks
0
40
80
120
160
Scale of Chains.
R. H. Irwin. Del. 1899.

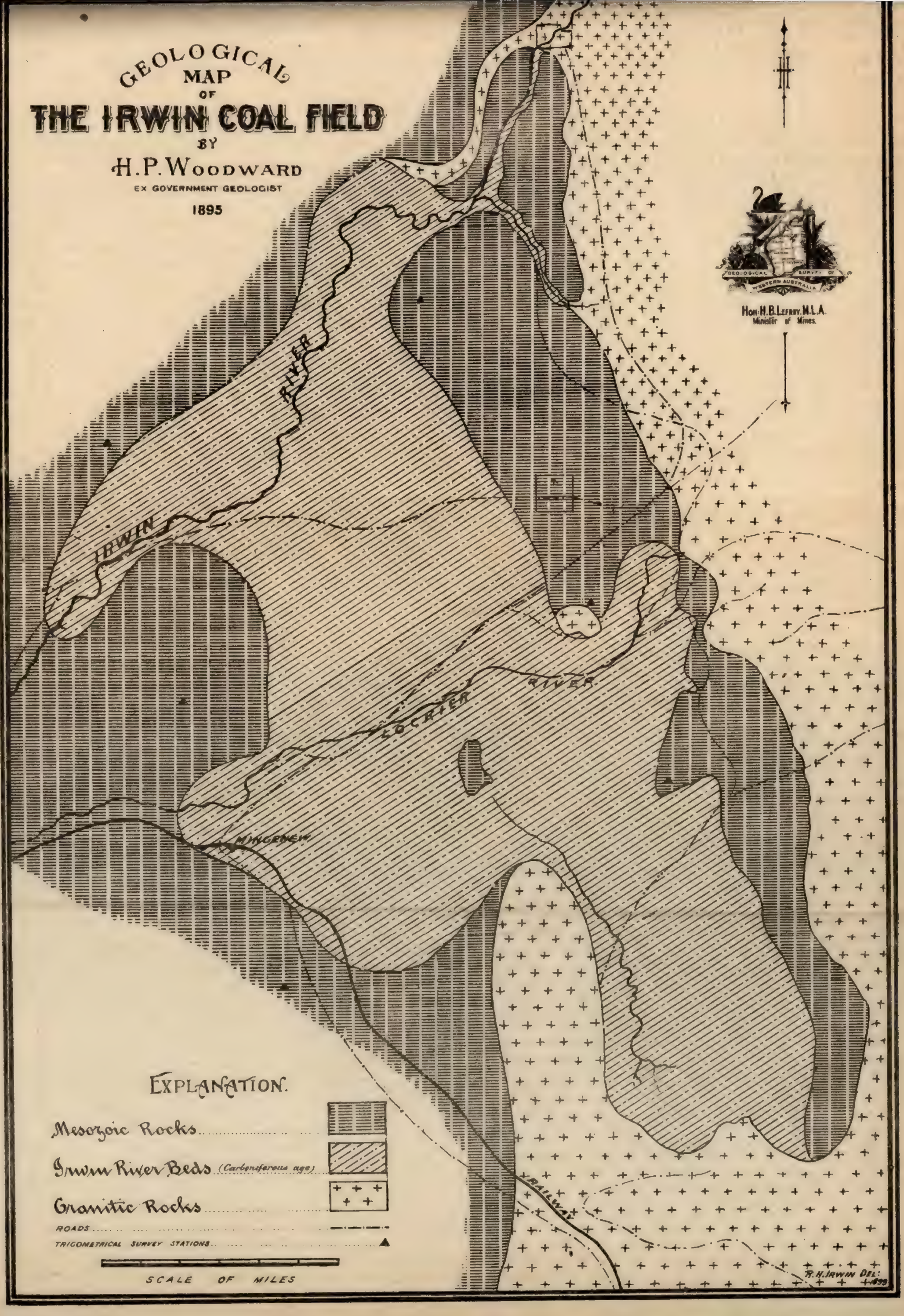
GEOLOGICAL MAP
OF
WESTERN AUSTRALIA
TOWNSHIP
OF
NORTHAMPTON
NOKENENA
BROOK
CREEK
RAILWAY
No 18


GEOLOGICAL MAP
OF
NORTHAMPTON
BY
A. GIBB MAITLAND.
GOVERNMENT GEOLOGIST.
Hon. H. B. Lefroy, M.L.A.
Minister of Mines.
TOPOGRAPHY FROM PLANE TABLE SURVEY BY THE LATE S. J. BECHER
1897
Scale of Chains
EXPLANATION
ALLUVIUM
SANDSTONE & CONGLOMERATE
(Age Undetermined)
GNEISS, MICA SCHIST, QUARTZ SCHIST &c.
(Archaean?)
DIORITE DYKES
ROADS
TRIGONOMETRICAL SURVEY STATIONS
TOWNSHIP
OF
NORTHAMPTON
NOKENENA BROOK


THE CO
FERRUGINOUS C
COLLIE RIVER BE
GRANITE AND SCH
R. H. IRWIN. DEL 1899.


RAILWAY
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
HON: H. B. LEFROY. M.L.A.
Minister of Mines.
GEOLOGICAL MAP OF
THE COLLIE COAL FIELD
BY
A. Gibb Maitland.
Government Geologist.
1899
SCALE
OF CHAINS.
EXPLANATION
FERRUGINOUS CONGLOMERATE (RECENT)
COLLIE RIVER BEDS (COAL BEARING AGE?)
GRANITE AND SCHISTOSE ROCKS (AGE UNDETERMINED. ARCHAEAN?)
R. H. IRWIN. DEL 1899.


GEOLOGICAL MAP OF THE IRWIN COAL FIELD BY H.P.W.
EXPLANATION.
Mesozoic Rocks.
Irwin River Beds (Carboniferous age)
Granitic Rocks
ROADS
TRICOMETRICAL SURVEY STATIONS
SCALE OF MILES
RAILWAY
R.H. IRWIN DEL: 1899


GEOLOGICAL MAP OF
THE IRWIN COAL FIELD
BY
H. P. WOODWARD
EX GOVERNMENT GEOLOGIST
1895
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
HON. H. B. LEFROY, M.L.A.
Minister of Mines
IRWIN RIVER
LOCKIER RIVER
MINGENEW
RAILWAY
EXPLANATION.
Mesozoic Rocks
Irwin River Beds (Carboniferous age)
Granitic Rocks
ROADS
TRIGONOMETRICAL SURVEY STATIONS
SCALE OF MILES
R. H. IRWIN DEL:


GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
MAP OF
WESTERN AUSTRALIA
Shewing
THE DISTRIBUTION OF USEFUL MINERALS
together with
THE GOLDFIELDS AND OTHER MINING DISTRICTS
BY
A. GIBB MAITLAND.
GOVERNMENT GEOLOGIST.
1899
SCALE OF MILES
KIMBERLEY GOLDFIELD
PILBARRA GOLDFIELD
W. PILBARRA
ASHBURTON G.F.
GASCOYNE G.F.
PEAK HILL G.F.
MURCHISON G.F.
EAST MURCHISON G.F.
Mt MARGARET G.F.
YALGOO G.F.
NORTH COOLGARDIE G.F.
NORTH EAST COOLGARDIE G.F.
YILGARN G.F.
COOLGARDIE G.F.
DUNDAS G.F.
COLLIE RIVER COAL M.D.
DONNYBROOK G.F.
GREENBUSHES TIN FIELD
PERTH
FREMANTLE
BUNBURY
GERALDTON
CARNARVON
ROEBOURNE
BROOME
DERBY
WYNDHAM
SOUTHERN CROSS
Tropic of Capricorn
SOUTH AUSTRALIA
INDIAN OCEAN
SOUTHERN OCEAN
GREAT AUSTRALIAN BIGHT
ARCHIPELAGO OF THE RECHERCHE
BUCCANEER ARCHIPELAGO
DAMPIER'S ARCHIPELAGO
SHARK BAY
EXPLANATION OF COLOURS & SIGNS
GOLD (Other than Goldfields)
DIAMONDS
COPPER
IRON
MICA
COAL
GOLDFIELDS
MINING DISTRICTS
LEAD
TIN
ANTIMONY
ASBESTOS
GUANO
GRAPHITE
STOCK ROUTES
RAILWAYS

1900.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 5.

THE PHILLIPS RIVER MINING DISTRICT,

BY

TORRINGTON BLATCHFORD, B.A., F.G.S.,

Assistant Government Geologist.

Issued under the authority of the Hon. H. B. Lefroy, M.L.A., Minister of Mines.

PERTH:

BY AUTHORITY: RICHARD PETHER, GOVERNMENT PRINTER.

1900

TABLE OF CONTENTS.

LETTER OF TRANSMITTAL.

Geological Survey Office,
Perth, 20th June, 1900.

THE HON. THE MINISTER OF MINES.

In view of the discoveries recently made in the Phillips River District, the Assistant Geologist was instructed to report upon the field. I have now the honour to submit his Report, together with an explanatory Map.

The special value of the Report consists in accurately recording the condition in which mining is at present being carried out, together with a brief description of the salient features of the field. It is gratifying to learn that the copper lodes not only are of considerable size but present all indications of permanency, and also that payable auriferous quartz reefs have already been discovered. Mention is made in the Report of the occurrence, near Cocanarup, of a granitic rock, of such a character as would indicate the possibility of tin being discovered in the locality.

The accompanying Map, it is unnecessary to add, makes no pretensions to accuracy in detail, but is only designed to show, in a general way, the location of the mines; it will, doubtless, prove of some service to the public, pending the production of an accurate topographical and lease map of the district. It is highly desirable that all mining regions be mapped upon such a scale as may be best suited to meet the requirements not only of the mining community but the public at large.

I recommend the Report and Map be published in Bulletin form, for public information.

A. GIBB MAITLAND,
Government Geologist.

Phillips River Mining District.

Location.—The Phillips River Mining District lies within the boundaries of the Oldfield District, which latter comprises part of the South-Western portion of the Colony. The centre of the present mining operations lies to the Westward of the Ravensthorpe Range, and occupies the central portion of the Mining District. Fairly well-formed tracks extend from Ravensthorpe to the following centres, viz., Cranbrook, Albany, Esperance, and Mary Ann Cove. Of these the three first are distant about 180 miles, so that the Phillips River Mining District may be roughly said to lie midway between Esperance and Albany. Mary Ann Cove is distant about 30 miles, and is the present port. A detailed account of the stages on the route from Cranbrook to Ravensthorpe will be found on the concluding pages of this report. The adult male population of the whole field is* about 100, all of whom, with one or two exceptions, are occupied in prospecting.

Contour of the Field.—With the exception of the Ravensthorpe Range, the surface of the Northern and central portions of the Phillips River Mining District is comparatively even, though numerous minor hills, covered as they are by dense thickets of mallee scrub intertwined with creepers, make walking a difficult and laborious matter. The Southern portion of the field, with the exception of the Eyre's Range, and several high points in its vicinity, is more even and less densely timbered. The general fall of the district is from North to South; the Phillips, Lee Steere, and Jerdacuttup Rivers being the principal outlets for the surface drainage. A geological sketch map of that portion of the Phillips River Mining District which embraces the present prospecting operations accompanies this Report. As this portion of the country was comparatively a blank on existing maps, and owing to the inclemency of the weather during my visit, roughness of the country, and want of sufficiently well defined and located land marks, accuracy as to details either in geological boundaries or positions of the various workings must not be looked for. The accompanying plan will serve the purpose, therefore, more as a diagrammatic representation than an accurate plan of that part of the field under immediate notice.

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* May, 1900.

Previous observations upon the District.—The Phillips River and surrounding district was visited by Mr. H. P. Woodward, late Government Geologist, in the year 1893, and referred to in the following terms:—

At Cocanarup, on the Phillips River, a sudden change of country takes place, the granite, which outcrops in all the valleys to the Westward, giving place to metamorphic and schistose rocks, with quartz reefs and diorite dykes. This formation extends through the Ravensthorpe Range as far as Carlingup, on the Jerdacuttup River, and is very probably the Southern extension of the Yilgarn belt of auriferous country, which, however, is covered by the sandstone tableland between the two points. Gold in small quantities has been found here, with copper and iron pyrites, therefore this range should be thoroughly prospected, and as there is a good patch of country here, and several good springs, this might be done during the dry season.*

Gold in quartz reefs seems to have first been discovered by Dunn Brothers, of Cocanarup, in the reef now known as the "Jim Dunn Wonder," in the early part of the year 1899. This discovery was soon followed up by the discovery of the Floater reef, by Kingsmill, Graig, Stephenson, and party, which, from its richness led to more extensive prospecting in the vicinity, and the subsequent finding of several other promising gold as well as copper deposits.

Geological Description.—Travelling on the Cranbrool to Cocanarup Road, the monotony of the geological and topo graphical features, with the exception of the Stirling Range, i very striking. This sameness is due to the fact that, with fev exceptions, the prevailing rocks are granitic, covered over onl in isolated places with the remnants of sandstone deposits of later geological age, and occasionally intruded by dykes of mor basic rocks. From Cocanarup Station to the Ravensthorpe Ranges and extending from Mt. Short to within about 10 miles o Mary Ann Harbour, the occurrence of these basic dykes is mor marked than in any other part of the route, and has, undoubtedly given rise to the fissuring of the granites and the subsequen forming of various lodes rich in gold and copper.

That the granite has been altered by subsequent intrusion i witnessed by the presence of gneissic granite at the junction lines and the occurrence, at several of these junctions, of garnets forme in the granite rock. It has been remarked by the prospectors tha such garnet rocks are indicators of the occurrence of copper ore several of the copper lodes having been found in the vicinity of th particular class of rock on this field.

* *Ad interim* Report of the Department of Mines for half year ending 30th June, 1894, p. 14.

The Ravensthorpe Range consists of much altered, probably sedimentary, rocks, since changed into banded quartzites, and now covered with nodular ironstones of the type prevailing in different parts of the Colony. Some 10 miles from Mary Ann Harbour the coastal limestones and sandstones are met with in unbroken series, though scattered patches of both are found a good deal further to the North. There is good reason to believe that Eyre's Range and surrounding peaks are of the same class of rocks as the Stirling Range. There was not sufficient time at my disposal to visit this portion of the field.

Nodular Ironstones.—An extensive deposit of nodular ironstone of the prevailing West Australian type covers most of the Ravensthorpe Range and some of the higher ground to the immediate South. The greatest thickness of the deposit is attained on Mt. Desmond, which occupies the South-Eastern end of the Range.

Banded Quartzites.—These rocks resemble much the quartzites of the Murchison type* and are evidently altered sedimentary rocks, probably sandstones which have been laid down on a granite bottom and afterwards subjected to conditions which have left them in their present contorted and altered form. There appears to be no evidence as to the age of these quartzites. The portions of these old beds which outcrop are so contorted and denuded as to render any accurate observations as to their strike and dip impossible.

Basic Rocks.—A microscopic examination of these rocks tends to show that they closely resemble the basic rocks found in the Coolgardie Goldfield. They vary from fine-grained hornblende rocks, probably of the diorite family, to an almost pure coarse-grained amphibole rock. These rocks are easily traceable in the field by the difference in vegetation, mallee thickets having a decided preference for growing on the denuded products of the basic rocks to that of the more barren products of the granite. Narrow belts of timber may be seen stretching away for miles, and preserving a general South-Westerly and North-Easterly direction, showing the course of many of the dykes most distinctly. The dykes for the most part are narrow and regular in their course, and emanate from probably a boss in the immediate vicinity of the principal mining operations, which has a thickness, in places, of not less than three miles. As a general rule the thickness of the dykes does not exceed several chains, often not more than a few feet.

* Annual Progress Report of the Geological Survey for the year 1897. Perth: By Authority, 1898; page 57.

Granitic Rocks.—The staple rock of the Phillips River Mining District, however, is granite. This class of rock varies enormously both in form and composition. Coarse-grained micaceous granite is the prevailing type in which the mica and feldspar are often found in large separate bodies; in fact, prospectors have attempted to mine the former for a commercial product. The finer-grained felsitic varieties are often met with.

About two miles to the South of Cocanarup Station Homestead, a large belt of coarse-grained tourmaline granite outcrops for a considerable distance; well-formed tourmaline crystals may here be seen in much of the rock. In this locality greisen and graphic granite also abound, and at one point a pink mica, lepidolite, may be seen in considerable quantity. Crossing the main creek, about half-a-mile South of the "Central Camp," a belt of tourmaline granite, about two to three chains wide, containing extremely large crystals of spodumene,* crosses the country for a considerable distance in a North-West and South-East direction. In places, where the granite has been intruded by the basic dykes it is rendered more or less gneissic, and is, as a rule, impregnated with garnet crystals, varying in size from mere specks to crystals having a face dimension of one-quarter of an inch.

Lodes and Reefs.—In so far as prospecting has shown, the lodes being worked in the Phillip's River Mining District consist of fairly regular bodies of copper ore, in which a considerable amount of gold and silver is said to exist. The copper ore, as a rule, consists, in the oxidised zone, of blue and green carbonates of copper, grey copper ore, a small amount of oxides of copper, and, usually, a rather large percentage of quartz and oxides of iron. Below the oxidised zone, the ore consists of massive sulphides of copper and iron. These latter conditions may be seen in two mines only. As will be seen in reading the detailed descriptions of the workings, the lodes attain to considerable size, and, up to the present, have every appearance of permanency at lower depths. The copper lodes usually occur in the near vicinity of the basic rocks; a basic rock in some instances forming one wall, while granite forms the other. The lodes may therefore be looked upon as belonging to the true fissure type. The occurrence of the payable quartz reefs is of a somewhat similar nature to the lodes, only that in many instances the reef is found in the granite or basic rock and not along the junction line of the two. As usual on the Eastern fields, there appear to be two classes of quartz reefs; the larger and more

* Silicate of alumina and lithia.

defined class, consisting of large bodies of milky white quartz free from gold, while the others are usually of less size, more clear and glassy in appearance, and usually heavily charged with oxides of iron. The last class contains most of the gold. In most instances the gold in the quartz reefs is not of a coarse nature, very fine gold being the order of things. There are numerous cases, however, in which the gold is found in "rough" pieces, having a weight of several grains. The gold is well distributed throughout the stone, and in consequence there has not been much chance of abstracting much of the metal by means of the dolly pot, as was the case on most of the Eastern and Northern fields. Though copper is a frequent associate of the quartz, it is gratifying to see that, where copper does occur in appreciable quantities, the percentage is great enough to enable the stone to be classed as a copper ore.

THE MINES.

The following are descriptions of the mines as personally seen in the month of May, 1900. To facilitate reference to the accompanying plan the order of the mines is taken from North to South:—

Glasgow Gold Mine.—One reef, striking North-East and South-West, and underlying at a high angle to the North-West, may be traced by irregular patches of floaters for a considerable distance throughout the lease. A shaft, having a vertical depth of 33 feet, has been sunk on the reef, which maintains an average thickness of about two feet to the bottom of the shaft.

The country hereabouts is much broken by intruding basic dykes, and, in consequence, the reef partakes of this nature; the quartz vein being irregular in habit. The quartz is white and milky with a small amount of included oxides of iron and free visible gold. No further work has been done at present to open up the reef.

Hardy and Forster's Gold Mine.—This mine lies at a distance of about 18 chains North-East from the Glasgow Gold Mine. The quartz reef, which can be traced by its outcrop, strikes North-North-East and South-South-West. Two shafts have been sunk on the reef. Of these the more Southern has a vertical depth of 33 feet. The reef, which has an almost vertical underlie, has been followed in this shaft, and maintains an average thickness throughout of at least two feet, whilst a body of quartz, with a thickness of three feet, may be seen in the bottom of the shaft. The reef at the lowest level underlies perceptibly to the West-North-West. The hanging wall is not determinable, though a good granite footwall can be clearly distinguished. A second shaft, situated at a distance of about 50 feet North-North-East from the first, has a vertical depth of 20 feet. The reef in this shaft is not so well defined; the country rock being more decomposed than in the preceding shaft. The quartz is clear and glassy, contains much iron oxide, and carries an appreciable amount of visible gold. Green copper stains show the presence of a small percentage of copper in the quartz.

Maori Queen Gold Mine.—On the Maori Queen Gold Mine, the outcrop of a large quartz reef can be seen extending in a North-East and South-West direction throughout the length of the lease. At the North-East end, the reef apparently turns to the North-

North-East. This deviation may be due to bifurcation, as sufficient development has not been done to prove conclusively to what the change of strike is due. Two underlay shafts have been put down on the reef at a distance of one chain apart. The South-Western one has a vertical depth of 22 feet, and follows the reef down for the whole distance. The underlie of the reef is about one in five. The average width of the reef in the shaft is four feet. Fine grained muscovite granite forms the footwall, while a much altered hornblende rock is seen on the hanging wall. The North-Eastern shaft has also been sunk on the underlay to a vertical depth of 53 feet. Though the width of the reef is not so great in this shaft (the average being about two feet only) still the quality of the stone is better, free gold being visible in much of the quartz. The quality of the quartz varies for different portions of the reef. Most, however, of the stone at grass is clear and glassy, with a considerable amount of iron. A fair amount of the stone, however, assumes a more milky white appearance. The quartz in the North-Eastern portion of the reef is for the most part ferruginous, and to all appearances the most promising as a gold bearer. Similar walls may be seen in this shaft, as in the one to the South. No crushings of stone taken from this mine had been made up to the date of my visit.

The Floater Gold Mine.—This was the first rich mine discovered in the vicinity of the Ravensthorpe Range, from which it lies at a distance of some two to three miles to the Westward. At present only one shaft, having a vertical depth of 35 feet, has been sunk on the reef, which lies at a distance of several feet beneath the true surface. The reef does not outcrop at the surface. As the shaft has not revealed the walls, the thickness of the quartz body being too great, little can be seen at present. The quartz is for the most part clear and glassy, heavily charged with oxides of iron, and carries a large quantity of fine gold, evenly distributed throughout the stone. About 200 tons of quartz carrying a considerable amount of gold is at grass ready for treatment.

Mount Catlin Copper Mine.—The lode on this mine strikes North 70° East and South 70° West, with scarcely perceptible underlie. The main shaft has a vertical depth of about 30ft., and has been sunk on the lode. At the bottom of the shaft a crosscut is being put in to the North, and has proved the lode to be of a greater width than 25ft. The Southern wall consists of massive hornblende rock, whilst the country to the North consists

of garnetiferous gneiss. At present the lode is considerably mixed with gangue. Blue and green copper carbonates, grey copper ore, and red oxides are the prevailing copper minerals in the higher levels, though they are being replaced by the yellow sulphides at the bottom of the shaft. The cap of the lode can be traced for a considerable distance on the surface, and gives every promise of being one of the largest lodes on the field. No ore has been shipped or treated from this mine to date. Samples of the grey copper taken from the lower levels of this mine yielded at the hands of Assayer of this Department 38·43 per cent. of copper, with 5oz. 17dwts. of silver, and 4dwts. of gold per ton.

Lady Annabel Gold Mine.—Two shafts have been sunk on this lease, on a reef striking North 30° East, with an almost vertical underlie. The Southern of these two shafts has been sunk to a vertical depth of 25ft. on the reef. The average thickness of the reef in this shaft is about 2ft. Free gold may be seen in much of the stone, which is of the clear glassy variety, and heavily charged with oxides of iron. Gold is also visible in the quartz in the sides of the shaft. The country rock is compact hornblende rock. The Northern shaft is situated at a distance of about 150ft. from the Southern shaft, and has been sunk to a vertical depth of 45ft. The water level, however, is at a vertical depth of about 37 feet from the surface, so that the workings below this level are not visible. The water is salt. The reef, to the 37 feet level, has an average thickness of about two feet, and carries free gold. Below this level the oxides of iron are replaced by massive sulphides of iron. No outcrop of this reef is visible at the surface, the reef being covered over by a layer of earthy detritus several feet in thickness. The country rock in the Northern shaft is of a fine-grained hornblende variety, probably belonging to the diorite family. Several costeens in the Northern portion of the lease show the presence of a quartz reef which may be a continuation of the main reef, but at present such is not definitely known to be the case, though the strike, however, points to this conclusion. A parallel quartz leader has been discovered at a distance of about three chains to the East of the main lode.

Cousin's Glory Gold Mine.—This lease lies to the East of the Lady Annabel. Up to the present two shafts have been sunk to a vertical depth of about 30 feet on two parallel quartz veins. The more Eastern of these attains a thickness of about 18 inches. The quartz is heavily charged with iron oxides, and carries visible free gold. Prospecting, however, has been carried on to a very limited

extent only. The same remark is applicable to the Western reef, on which a shaft of a vertical depth of 22 feet has been sunk. Here the reef is about one foot in thickness and of lower grade. Small quantities of carbonate of copper occur in these reefs. The strike of the reefs is to the East of North with a variable underlie to the East. The country rock is fine-grained hornblende rock.

Jim Dunn Wonder Gold Mining Lease.—The quartz reef being worked on this lease strikes about 12 degrees to the East of North. A distinct outcrop of the reef may be traced on the surface for at least half-a-mile. An underlay shaft follows the reef for a vertical distance of about 80 feet. The underlie of the reef for this distance is about 45 degrees to the East. Past the ...

... has been put down to a ... depth of 45 feet. The average thickness of the reef in this shaft is about five feet. At the bottom of the shaft, however, the reef apparently branches into two quartz bodies, each having a thickness of about 1ft. 6in. The nature of the quartz in this shaft is similar to that of the main shaft. No crushings of the stone taken from these shafts have been made to date. Several other quartz reefs may be seen outcropping in the vicinity of the above-mentioned workings; the principal of these is a large quartz outcrop striking East and West, and underlying to the North, at a distance of about half-a-mile South of the main workings. The quartz in this outcrop is white and opaque, but carries small quantities of gold. Unfortunately the intersection of these two lines of reef has not been discovered.

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Jim Dunn Wonder Gold Mining Lease.—The quartz reef being worked on this lease strikes about 12 degrees to the East of North. A distinct outcrop of the reef may be traced on the surface for at least half-a-mile. An underlay shaft follows the reef for a vertical distance of about 80 feet. The underlie of the reef for this distance is about 45 degrees to the East. Past the 80-feet level, the reef suddenly underlies at a much higher angle for a distance of some 12 feet, and then apparently assumes its ordinary course. A considerable diminution in thickness occurs in this interval, the reef being of very small dimensions. In the bottom of the shaft however the reef has a thickness of several feet. Both walls are granite, and are well defined and regular, the hanging wall in particular being perfectly smooth and polished. At the 80-feet level a short crosscut was put in to the East and a drive extended to the North for a distance of some 40 feet when a large body of quartz 10 feet in thickness was met with and followed for some 30 feet; this is without doubt the same reef, and was missed in the shaft owing to unskilful mining. There seems every probability of the reef proving a continuous one, as there is every indication of its belonging to the true fissure type. In the 80-feet level bunches of iron pyrites are met with in considerable quantity. Free gold is seen in some of the stone. The quartz is whitish and glassy in appearance. The reef in the shaft averages about four feet in thickness. At a distance of about four chains to the North of the main shaft another underlay shaft has been put down to a vertical depth of 45 feet. The average thickness of the reef in this shaft is about five feet. At the bottom of the shaft, however, the reef apparently branches into two quartz bodies, each having a thickness of about 1ft. 6in. The nature of the quartz in this shaft is similar to that of the main shaft. No crushings of the stone taken from these shafts have been made to date. Several other quartz reefs may be seen outcropping in the vicinity of the above-mentioned workings; the principal of these is a large quartz outcrop striking East and West, and underlying to the North, at a distance of about half-a-mile South of the main workings. The quartz in this outcrop is white and opaque, but carries small quantities of gold. Unfortunately the intersection of these two lines of reef has not been discovered.

Marian Copper Mine (*Kingsmill & Martin*).—The general strike of the lode on this mine is North 50° East, with an almost vertical underlie. Three prospecting shafts have been sunk on the lode, covering a distance of about 14 chains. The most Southern of these shafts, which has a vertical depth of eight feet, shows the lode to have a thickness of about three feet, and to consist principally of blue and green carbonates of copper with a small percentage of red oxide of copper. One ton of blue and green carbonate copper ore has been bagged ready for shipment. Number two shaft, situated at a distance of three chains from the Southern shaft, also has a vertical depth of eight feet. Here the lode is about four feet in thickness and underlies to the North-West. The lode here consists more of grey ore than the carbonates, and is more compact than in the Southern shaft. About two and a-half tons of the grey ore are ready bagged for shipping. The Northern shaft, situated about 11 chains distant from the Central shaft, has a vertical depth of 15 feet. The lode here consists of grey ore mixed with blue and green carbonates. The thickness of the lode varies, the average being about 3 feet 6 inches. Eight tons of ore are ready bagged from this shaft. The country rock is difficult of determination owing to its weathered state; garnetiferous granite, however, may be seen outcropping at a short distance to the West of the lode. Samples taken from the bagged ore yielded the following assay returns:—

	Copper.	Silver.	Gold.
		per ton.	per ton.
1. Most Southern Shaft ...	27·72 per cent.	2ozs. 10dwts.	1dwt. 15grs.
2. Central Shaft	27·26 „	1 „ 9 „	3 „ 6 „
3. Northern Shaft	30·48 „	0 „ 19 „	7 „ 7 „

Kingston Copper Mine.—On this property, the outcrop of a copper lode has been followed and opened up for a distance of several chains. One shaft has been put down to a vertical depth of 35 feet on the lode, which strikes East 15° North and West 15° South, and has a thickness of some 4 feet. The lower levels of the shaft were not visible for inspection owing to a blockage arising from re-timbering and altering the size of the shaft. A considerable amount of blue and green carbonate copper ore has been taken out whilst sinking the shaft, but to date no returns as to its intrinsic value are to hand. The country rock is much altered hornblende rock. A sample taken of the oxidised ore yielded 32·70 per cent. copper, 1oz. 9dwts. of silver, and 9dwts. 19grs. of gold per ton.

The Mary Copper Lease (Garritty and Filewood).—Two distinct parallel copper lodes, about eight chains apart, can be traced throughout the greater portion of this lease. Their course is approximately East and West. The Southern of these two lodes has been exploited by two shafts about three chains apart.

South Lode.—The Eastern shaft has a vertical depth of about 30 feet. To the 20 feet level the lode has a width of about five feet, and consists of blue and green copper carbonates, mixed with grey ore and earthy copper oxides. At the 25 feet level this class of ore suddenly changed into heavy sulphide ore with an average thickness of about two feet, though, at the bottom of the shaft, the lode attains a width of three feet. About 20 tons of carbonate ore mixed with quartz is at grass from this shaft. The lode is approximately vertical. The Western shaft has a vertical depth of about 15 feet, and is about three chains distant from the Eastern shaft. Similar ore has been taken from this shaft as from the Eastern shaft; only the green carbonate is in rather a larger proportion than the blue. The country rock is granitic, intersected by small bands of intrusive hornblende rock.

The Northern lode has not been opened out to any extent, though the outcrop can be clearly traced on the surface for 100 yards or more. It lies at a distance of some eight chains from the South lode, and is approximately parallel to the latter. A sample taken of the ore from the South lode yielded 26·48 per cent. copper, 1oz. 19dwts. silver, and 6dwts. 12grs. of gold per ton. Samples from the South-Western spur of this lode yielded 33·10 per cent. copper, 6dwts. of silver, and 19grs. of gold per ton. The oxidised ore of the Northern lode yielded 38·73 per cent. of copper, 2ozs. 5dwts. of silver, and 1dwt. 15grs. of gold per ton. A sample taken of the sulphide ore of the South lode yields an assay return of 1·98 per cent. copper, 19dwts. of silver, with a trace of gold per ton.

Federal Copper Lease.—One shaft has been put down on this lease to a vertical depth of 40 feet in a copper lode striking North 50° West and South 50° East, with a slight underlie to the South-West. The lode, which has an average thickness of about two feet, consists, in the first 14 feet from the surface, of blue and green carbonates, associated with quartz and oxides of copper and iron. From the 14 to the 35 feet level the copper carbonates give place to oxides of iron containing some oxides of copper and a fair proportion of quartz. Below the 35 feet level, massive sulphides, principally of iron, with a small proportion of copper pyrites, replace the oxides and carbonates. Up to the present no driving

has been carried on, or the lode opened up to any extent in other places at the surface. Well defined walls occur on each side of the lode. The casing of the walls is heavily charged with iron pyrites. In addition to the main lode, there are several indications on this lease of the occurrence of other lodes, but, to date, little or no prospecting has been done to open these up. The country rock is hornblendic, and probably of the diorite family. One sample of the sulphide ore yielded 33·49 per cent. of copper, 2ozs. 9dwts. of silver, with a trace of gold, per ton.

Ravensthorpe Gold and Copper Mine.—On this property prospecting is being carried on on a small ironstone lode, striking North 20° East, and underlying to the West at a high angle. The lode consists of oxides of iron mixed with carbonates and oxides of copper and quartz. The country rock is schist, which will probably be found to be of a hornblendic nature when the unweathered rock is reached. At present it is in too highly an altered condition to classify with any degree of accuracy. The prospecting shaft has only reached a vertical depth of 10 feet. An assay of the ore for gold yielded 3dwts. 12grs. of gold per ton.

Albania Gold Mine.—The Albania Gold Mine is situated near the Cocanarup to Mary Ann Harbour Road, and lies at a distance of 12 miles from the former locality. A quartz reef, running East and West, outcrops at the surface, and can be traced for a considerable distance through the property. One shaft has been sunk to a vertical depth of 40 feet, when the reef was struck and passed through; after this the reef was followed by an underlie shaft for a distance of some 10 vertical feet. The underlie of the reef is to the North at a high angle. In the bottom of the shaft the reef has a thickness of one foot six inches, though its dimensions higher up in the shaft are much greater. The quartz is of a white more or less milky nature, much honeycombed in places, and charged with oxides of iron. At about the 40 feet level the oxides of iron are replaced by massive sulphides of iron. Crushings of ore taken from this mine have not been made up to date. Several assays made at different levels show the presence of gold and silver in appreciable quantities.

Doctor Jim Gold Mine.—This mine lies to the South-East of the Albania Gold Mine, at a distance of about two miles. A large quartz reef, averaging about 3ft. in thickness, and striking North and South, outcrops at the surface for a considerable distance. The reef underlies to the East, at an angle of about 45 degrees.

One shaft has been sunk on the reef for a vertical distance of 20ft., when a drive was put in to the South for a short distance. This drive is now filled in. Further sinking was then carried on in an underlay shaft, which followed for a short distance probably a spur of the main reef. This spur strikes South-East and North-West. At the 20ft. level large bunches of copper ore were met with. These bunches included massive green and blue carbonates of copper, as well as grey copper ore and some copper pyrites. Several hundredweight of high grade copper ore were thus found. There seems every chance of a recurrence of these bunches, as they appear to be distinct from the quartz reef. The country rock in this mine is granite. On the surface, numerous basic dykes may be traced, as well as the outcrops of two apparently parallel quartz reefs. Little work has been done on any of the reefs in the vicinity.

There are no crushings or returns to record from this mine.

TORRINGTON BLATCHFORD, B.A., F.G.S.,
Assistant Government Geologist.

30th June, 1900.

Appendix A.

WATERING PLACES.

En Route to Ravensthorpe.

The following are the approximate distances between the watering places on the Cranbrook to Phillips River Route:—

	Distance in Miles.
Cranbrook to Yellermerup	23
Yellermerup to Warungup	11
Warungup to Mungup	15
Mungup to Flat Rock	10
Flat Rock to Night Well	30
Night Well to Jerramungup	10
Jerramungup to Cocanarup	58

During the winter months an abundance of water may be found lying on the granite rocks, but during the summer this supply cannot be relied upon.

Appendix B.

ASSAYS OF ORES.

No.	Description of Sample.	Copper, per cent.	Silver, per ton.		Gold, per ton.	
			ozs.	dwts.	dwts.	grs.
2227	Kingsmill and Martin, No. 1	30·48	0	19	7	7
2228	Do. do. No. 2	27·26	1	9	3	6
2229	Do. do. No. 3	27·72	2	10	1	15
2230	Do. do. No. 4	42·97	0	3	1	15
2231	Mt. Catlin	38·43	5	17	4	0
2232	Dr. Jameson	24·60	5	9	0	19
2233	Allan Bros., Oxides	26·18	2	2	0	19
2234	Do. Clean Sulphides	26·18	1	6	Trace	
2235	Kingston, Oxides	32·70	1	9	9	19
2236	Garritty and Filewood, Main Lode ...	26·48	1	19	6	12
2237	Do. do. Spur off Main Lode	33·10	0	6	0	19
2238	Do. do. North Lode ...	38·73	2	5	1	15
2239	Do. do. Heavy Sulphide	1·98	0	19	Trace	
2240	Garritty and Hammond	33·49	2	9	Trace	
2241	Allen Bros., Sulphides	...	*Nil*		Trace	
2242	Ravensthorpe Mine	...	*Nil*		3	12
2243	Dunn Bros.	...	*Nil*		*Nil*	
2390	Floater Mine, Typical Quartz	*Nil*	1	3	387	2

EDWARD S. SIMPSON, B.E., F.C.S.,

Mineralogist and Assayer.

29th June, 1900.

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1902.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 6.

Notes from the Departmental Laboratory,

BY

EDWARD S. SIMPSON, B.E., F.C.S.,
MINERALOGIST AND ASSAYER.

*Issued under the authority of the Hon. H. Gregory, M.L.A.
Minister for Mines.*

PERTH

BY AUTHORITY WM. ALFRED WATSON, GOVERNMENT PRINTER

1902.

CONTENTS.

ILLUSTRATIONS.

PREFATORY NOTE.

THE officers of the Departmental Laboratory occasionally make, in the ordinary course of their duties, important researches in connection with substances with which Geology is concerned.

It has hitherto been found almost impossible to give these isolated facts—the accumulation of which forms so essential a part of the labours of the Geological Survey—that publicity which their importance demands.

During the year 1900, the Mineralogist and Assayer, at my request, commenced the preparation of a pamphlet designed to include the results of the researches carried out in the Survey Laboratory since its inception.

It is hoped that this work—which is but an attempt to reduce the laboratory observations to a somewhat systematic form—will be the forerunner of a much larger one, dealing systematically with the distribution, mode of occurrence, and composition of the minerals, rocks, and ore deposits of Western Australia, material for which is being slowly accumulated.

A. GIBB MAITLAND,
Government Geologist.

Geological Survey Office,
Perth, 1st February, 1902.

DESCRIPTION OF PLATE I.

(1.) Lens-shaped obsidianite. Weight, 39·66gram. Size, 38 x 36 x 34 mm. Sp. gr., 2·43. Locality, unknown, but somewhere in Western Australia.

(2.) Lens-shaped obsidianite. Weight, 116·07gram. Size, 56 x 54 x 31 mm. Sp. gr., 2·42. Locality, about lat. 25° 30′ S. and long. 123° 0′ E.

(3.) Irregular obsidianite, approaching lens shape. Weight, 32·08gram. Size, 35 x 35 x 24 mm. Sp. gr., 2·44. Locality, same as (2).

PLATE I.—THREE LARGE WEST AUSTRALIAN OBSIDIANITES.
Scale: Three-quarters.

NOTES FROM THE DEPARTMENTAL LABORATORY.

Introduction.

The following notes are the outcome of a desire to present in a readily accessible and sytematic form the results of the chemical and mineralogical research work carried out in the laboratory of the Geological Survey of Western Australia during the past four years. These notes should prove of greater interest from the fact that, previous to the organisation of the department on its present basis in 1897, practically no work of this character had been attempted in the State, whilst little other than official information has been made available since that time. What few determinations of the chemical and mineral constitution of the rocks and ore deposits of Western Australia have been recorded by other observers are only to be found scattered through the pages of various scientific periodicals and proceedings and State Documents. Reference to many of these publications will be found in Bulletin I. of this Survey.

The practice prevails in most of the States of Australia of permitting the general public to have assays and analyses of mineral products made in the laboratories attached to the various Geological Surveys; and here, as elsewhere, advantage is largely taken of this privilege. In this State, which owes so much to the rapid development of its mineral resources, a further tax upon the time of the laboratory staff has been levied by reason of the erection and working of a number of Government stamp batteries throughout the auriferous districts. In consequence of this, and of the inadequate strength of the scientifically-trained staff of the laboratory, very little systematic research in any one direction has been possible. All that it was possible to do under the circumstances was to meet the more immediate demands for detailed knowledge in a number of different directions. The information, therefore, contained in the following pages is necessarily of a somewhat fragmentary character, and can only be systematised by continued efforts in the direction of supplying the missing links to our chain of facts in connection with those few subjects already taken in hand out of the innumerable ones which present themselves as the geological exploration of this vast State proceeds.

The main portion of the subject matter of this Bulletin has been so arranged as primarily to fall under the two divisions of Mineralogy (in its broadest meaning) and Petrology. No details of methods of analysis have been given, these being largely those of the ordinary text-books of Fresenius, Hillebrand, etc. Except where otherwise stated, all the analyses have been made by the author.

Since the issue of the Census of Minerals of Western Australia in Bulletin No. 4 of this Department, so many fresh occurrences have been noted that it has been deemed advisable to add a list, which is supplementary to that already published. These new localities accordingly appear as Part III.

PART I.

Mineralogy.

GOLD.

A.—Forms in which gold occurs.

Gold forming by far the most important mineral product of the State, considerably more attention has been directed to its occurrence than to that of any other mineral. So far, it has been found to occur under three distinct forms, viz.:—

(1.) The native metal

(2.) Compounds with tellurium

(3.) Compounds with other elements.

(1.) Native Gold.

Composition.—Mr. Wallace, the Statist to the Department of Mines, estimates the average fineness of the gold produced during

1900 at 88·05, of a value of £3·741 per oz. So many impurities may, however, be added to, or removed from the gold, during the process of extraction from its ores, that these figures give only a very crude idea of the average composition of the native metal. That its fineness varies very largely in different parts of the State, and follows no rule as to latitude or longitude, is shown by the analyses in Table I., all of which were made on carefully-cleaned specimens of the native metal.

TABLE I.—*Composition of Native Gold.*

No.	Nature of Gold.	Locality.	Specific Gravity.	Gold.	Silver.	Copper and Iron.
				%	%	%
1	Small alluvial nuggets	Hall's Creek, Kimberley	16·62	93·30	6·60	·10
2	Three-ounce alluvial nugget	do. ...	16·80	88·39	11·61	...
3	"Bobby Dazzler" nugget	Shark's Gully, Pilbarra	14·66	76·81	23·04	·15
4	Gold from quartz boulders	Talga, Pilbarra	16·20	84·46	15·54	...
5	Gold from conglomerate	Nullagine, Pilbarra	...	91·21	8·79	...
6	Gold from quartz reef	Bamboo Creek, Pilbarra	...	94·00	6·00	...
7	Do. do. ...	Towranna, Pilbarra	...	94·53	5·47	...
8	Do. do. ...	Peak Hill, Peak Hill	17·16	96·54	3·46	...
9	Do. do. ...	Nannine, Murchison	15·75	89·45	10·50	...
10	Sponge gold from lode	Boulder, Kalgoorlie, East Coolgardie	...	99·91	·09	*Nil*
11	Coarse gold from ironstone pebbles	Block 50, Coolgardie	18·91	99·46	·64	Trace
12	Crystalline gold from calcite vein	Red Hill, Coolgardie	18·00	93·21	6·72	...
13	Gold from alluvial ...	Preston River, South-West	...	92·90	7·10	...
14	Electrum from quartz reef	Donnybrook, Donnybrook	...	49·29	50·71	...

Varieties.—Several varieties of native gold are recognised by the miners in this State, the name by which they are known being generally descriptive of their outward appearance. The following terms are in general use:—

Crystalline Gold.—Characterised by the more or less regular development of crystal faces. The most perfect crystals yet observed are in the form of single octahedrons, embedded in asbolite

(oxide of cobalt and manganese) in a soapy clay from Kanowna, locally known as "pug." The largest of these crystals is not more than ·02 inch in diameter. Coarse gold, with well-developed crystal faces, has also been noticed at Bulong, Kalgoorlie, and Red Hill (C).; at the latter place in a vein of calcite. A single cubical crystal from Norseman had three faces about 1 inch long fully developed, and other faces partly so. Some excellent specimens of gold from Bulong, which were sent to Paris for exhibition, showed triangular groups of crystal faces developed on the surface of flat sheets of the metal.

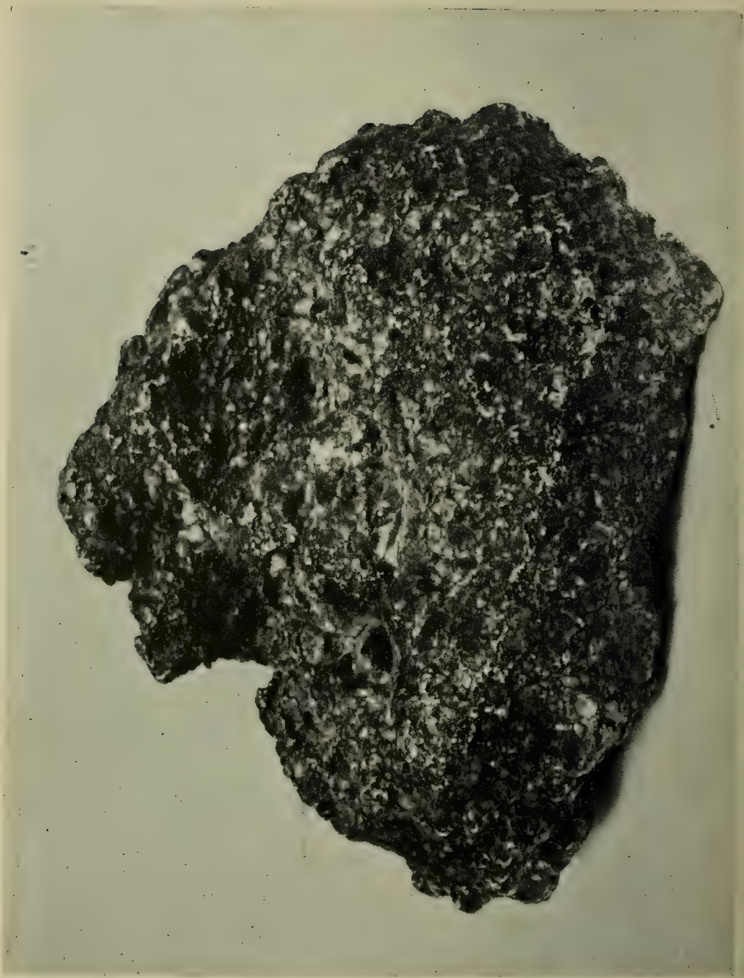
Dendritic Gold.—This fern-like form is closely related to the previous one, being due to incipient crystallisation. Beautiful examples of this nature are very common in the sintery quartz of Donnybrook.

Rough Gold.—The usual form in which gold occurs in reefs, being irregular in form, and having no one dimension markedly greater than any other.

Flake Gold.—This form, so dreaded by the miner on account of the ease with which it floats on water and escapes amalgamation, owes its peculiarities to being not thicker than gold leaf. It is invariably found on the faces of cleavage and foliation planes of its matrix. Excellent specimens of flake gold have been obtained from Mulline (N.C.) and Kanowna (N.E.C.) in kaolin; Kalgoorlie (E.C.) and Coolgardie in diabase schists; and elsewhere.

Mustard Gold.—In the oxidised zone of many gold mines, particularly at Kalgoorlie, much of the gold occurs in the form of an extremely fine, dull, yellow powder, thought to be the residue left by the oxidation of gold tellurides or highly-auriferous sulphides. Mt. Magnet has also furnished some fine examples of this kind. Mustard gold is extremely difficult to amalgamate, owing to its fine state of division; but for this very reason is readily extracted by the cyanide or other solvent processes.

Sponge Gold.—This is undoubtedly the product of oxidation of gold tellurides, being found only in the surface ores of those Kalgoorlie Mines which have yielded tellurides in depth. To the naked eye it has all the structure of a marine or vegetable sponge, consisting of loosely coherent, irregular strings and cellular masses of brilliant metal. Some of it at least is remarkably pure, much more so than any other gold heretofore analysed, as is shown by the analysis of a sample from the Golden Horseshoe Mine, given above. The most extensive development of this form of gold ever recorded was in the 200ft. level of the Great Boulder Proprietary G.M., where, in a few hours, on 19th March, 1897, about 70lbs. weight of pure sponge gold was taken out of a vugh. One piece alone weighed 60ozs., and altogether 250ozs. were exhibited by the management in one of the shop windows in Kalgoorlie on the following day.



W.A. Newspaper Co.

Plate II.—Clive's "Bobby Dazzler" Nugget.
Scale: One-half.

Alluvial Gold.—Enormous quantities of alluvial gold, in pieces ranging from the finest dust up to Clive's nugget (Plate II.) of 480ozs., have been won from the surface and deep alluviums of the State. That this gold is mechanically derived from primary deposits is now practically decided by the light of recent researches. One great objection to this theory, viz., the supposed marked difference between the size of the largest masses of gold found in reefs and lodes and that of the largest alluvial nuggets, has frequently been disproved in this State by the discovery of enormous pockets of gold in the primary deposits. As instances of this, take the mass of sponge gold referred to in the previous paragraph, or the huge masses of almost solid gold found in the outcrops of the reefs at Bayley's (Coolgardie), Londonderry, and Wealth of Nations. More recently specimens have been valued in the department consisting of quartz and gold from a reef at Nannine (M.), one of which weighed 1,221ozs. gross, and contained 340ozs. of gold, whilst the total of several pieces broken out of one pocket by a single charge of dynamite amounted to 2,616ozs. gross, containing 778ozs. of the precious metal. Such a pocket, if shed from the reef by natural weathering and subjected to the battering action of moving stones, etc., would soon lose almost all its quartz, and be hammered into a nugget which would rival any hitherto found in the alluvial deposits of this part of Australia. Witness again the "Joker" slug of 303½ozs. of practically pure gold, broken out of a small reef 6ft. below the surface at the Devon Consols Mine, Black Flag, in December, 1895. At the Mainland, again, a pocket weighing in all 400lbs. yielded 556oz. of clean gold. The so-called "Monarch" nugget* was nothing more nor less than a mass of quartz and gold, quite devoid of all traces of water action, and found immediately alongside the reef from which it had been shed; whilst the "Bobby Dazzler," * though showing evident signs of the action of moving water, still carried 16 per cent. by weight, or 50 per cent. by volume of ferruginous quartz, through which the gold ran in strings and irregular pieces. One side, which had been pointing up stream and had received the brunt of the shocks of moving boulders, presented a face of almost solid gold, the quartz having been splintered and washed away. It seems evident, therefore, that some at least of the larger alluvial nuggets have been originally rich pockets in reefs, carrying perhaps not more than 10 per cent. of gold, and held together by comparatively brittle quartz, which has yielded to the shocks experienced after being shed from its matrix, whilst the gold has been welded into a more or less solid mass. It is possible that the internal crystalline structure observed in many nuggets may be a secondary structure set up after its consolidation by the shock of impact of moving bodies just as has been observed in the case of iron.

Unfortunately, in the early days of gold-mining, it was impossible to collect information of the many large nuggets which

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* *Vide* Table II., page 12.

were undoubtedly found. The following table (II.), however, contains details of some of the largest discovered in the State:—

TABLE II.—*Alluvial Nuggets found in Western Australia.*

Name.	Locality.	Date.	Finder.	Weight. Gross.	Weight. Net.	Character.	Remarks.
"Bobby Dazzler"	Shark's Gully, Coongan River, Pilbarra	1899	A. Clive	487·13	413·37	Gold with ferruginous quartz and travertine	Specific gravity, 8·714; valued at £1,348 9s. Exhibited in Paris, 1900; Glasgow, 1901. *See* Plate II.
"General Gordon"	Shark's Gully, Coongan River, Pilbarra	1899	Wm. & A. McPhee	372·0	331·8	... ...	Valued at £1,075. Found on same claim as "Bobby Dazzler."
"Little Hero," or "Pantomime"	Pantomime Gully, Coongan River, Pilbarra	1890	Doyle	333·4	.	... ...	Pantomime Gully is only two miles south of Shark's Gully.
"Monarch"	Wiluna, East Murchison	Dec., 1897	P. Martin	463·8	248·9	Gold and ferruginous quartz	Photo. appears in *Western Mail* of 18th March, 1898.
	Kurnalpi, North-East Coolgardie	Oct., 1900	W. Eddy	197			
	Kurnalpi, North-East Coolgardie	1899	J. Simmonds	168			
	Croydon	1896?	Anderson	160			
"Coolgardie"	Coolgardie (Pig Flat)	1901	W. Abbott	145·4	...	Gold with a little clay ...	Valued at £581 12s. Exhibited in Glasgow, 1901. *See* Plate III.
	Mt. Monger, North-East Coolgardie	May, 1899	...	135			
	Horseshoe, Peak Hill	...	...	125			
	Hogan's Find, North-East Coolgardie	1899	...	125			
	Kurnalpi, North-East Coolgardie	1898	Simmons & Hart	109·5			
	6-Mile, near Kanowna, East Coolgardie	1898	Millar	103	103	Clean gold.	
	Mt. Monger, North-East Coolgardie	May, 1899	...	102			
	Cue, Murchison	1892	Peryman	100			
	Lake Austin, Murchison	1892	J. Pearce	90			
	Top Camp, Ashburton	1893	...	87			
	Bulong, North-East Coolgardie	1898	Byrne	80			
	Bulong, North-East Coolgardie	1898	Dawson	75			

TABLE II.—*Alluvial Nuggets, etc.*—continued.

Name.	Locality.	Date.	Finder.	Weight.		Character.	Remarks.
				Gross.	Net.		
	Hogan's Find, North-East Coolgardie	1899	...	64			
	Mt. Mortimer, Ashburton	1896	...	60			
	Bulong, North-East Coolgardie	1898	Rampling	53			
	Black Hills, North-East Coolgardie	Dec., 1901	P. Moran	52·57	52·57	Clean gold.	
	Kurnalpi, North-East Coolgardie	July, 1901	Hogan & O'Connor	51			
	Black Hills, North-East Coolgardie	Oct., 1901	E. Dighton	50·8			
	Coolgardie, Coolgardie	1901	C. Woods	50·5	50·5	Clean gold	Valued at £197. Exhibited in Glasgow, 1901. *See* Plate III.
	Hogan's Find, North-East Coolgardie	1899	...	50			

No account of the nuggets of Western Australia would be complete without some reference to the famous "Golden Sickle" or "Sacred" nugget. On 19th July, 1898, intense excitement was caused throughout the Eastern Goldfields by the circulation of a report that a monster nugget had been discovered on the previous Sunday, on hitherto unprospected ground, close to Kanowna. It was reported to be 15 inches long, of the shape of a sickle, and to weigh 1,636ozs. Its value was estimated at £6,500. It was immediately christened, its names having reference, one to the day of its discovery, the other to its shape, but no one, except the person with whom it was said to have been lodged, was allowed to see it, nor would this person disclose the exact locality where it was found. Considerable dissatisfaction was exhibited by the mining community at this secrecy, increasing to such a pitch in a few days that at last it was promised that, although the nugget itself was not to be shown or its present whereabouts, or the names of its finders, revealed, the exact locality where it was found would be publicly announced from the balcony of a certain Kanowna hotel at 2 o'clock on 11th August. Long before that hour a crowd, numbering some 8,000, had collected in front of the hotel, provided with buggies, bicycles, etc., in readiness to set out at once for the scene of the discovery. Punctually to time, the gentleman previously referred to appeared on the balcony, and, after some preliminary words, announced that "the nugget was found a quarter of a mile this side of the nearest lake (Lake Gwynne), on the Kurnalpi Road." A wild stampede took place to the spot indicated, and hundreds of acres of ground were pegged out. No gold was, however, apparently found by any of those who pegged, and this fact, combined with the unreasonable mystery surrounding the nugget, soon caused people to become sceptical as to the truth of the original report. Although the nugget was authoritatively stated to have been lodged at the Union Bank in Coolgardie, the manager of that bank declared he knew nothing whatever about it. This, combined with the fact that no large nugget ever reached any of the mints, or was entered for export, confirmed the growing impression that the whole thing was a hoax; and from that day to this nothing further has been heard of either the "Sacred" nugget or its discoverers.

(2.) Tellurides of Gold.

Gundagai (N.S.W.), Mount Morgan (Q.), and Kalgoorlie are the only mining centres in Australia where tellurides of the precious metal are known to occur, and at Kalgoorlie (Boulder) they undoubtedly occur more freely and in larger masses than anywhere else in the world. They were first detected in 1896, and this discovery created at the time a considerable stir, owing to the prevalence of the opinion that these minerals were a sure indication of the extension of payable ore to unlimited depths.

The most frequently occurring mineral is calaverite, whilst petzite, goldschmidtite, and two new minerals, kalgoorlite and

Plate III.—Two Nuggets found at Coolgardie in 1901.

coolgardite, are also found in several of the mines. The following is a description of these minerals as they occur at Kalgoorlie:—

Calaverite.—Massive, crystalline, extremely brittle: cleavage, in several cases a single very perfect cleavage has been observed. [N.B.—The cleavable variety is considered by Krusch * to be krennerite, which Dana describes as the type species of which calaverite is only a variety.] Fracture, uneven to conchoidal; hardness, 2·5; specific gravity, 8·1-9·4; lustre, metallic brilliant; colour, silver-white to nickel-white or brass-yellow. Opaque. Composition, bitelluride of gold, a small proportion of which is replaced by silver. Formula, $AuTe_2$, requiring gold, 43·6 per cent.; tellurium, 56·4 per cent. Analysis: All the available analyses are collected in Table III.

TABLE III.—*Analyses of Kalgoorlie Calaverite.*

Number. Description.	I. Calaverite.	II. Calaverite.	III. ?	IV. ?	V. Krennerite.	VI. Calaverite.	VII. Calaverite.
Gold, Au ...	41·37	41·76	38·70	42·6	36·60	37·51	33·90
Silver, Ag ...	·58	·80	1·66	·7	3·82	2·06	4·82
Copper, Cu ...	...	...	·21	...	...	·29	·63
Iron, Fe ...	...	...	·18	...	...	·09	Trace
Nickel, Ni ...	...	...	...	...	...	·07	...
Lead, Pb ...	...	...	Trace	...	...	...	...
Bismuth, Bi ...	...	...	Trace	...	...	...	...
Zinc, Zn ...	...	...	Trace	...	...	...	...
Tellurium, Te ...	57·27	56·64	59·69	54·1	58·63	58·63	60·30
Selenium, Se ...	...	...	...	...	...	1·13	...
Sulphur, S ...	...	...	·09	...	...	·10	...
Total ...	99·22	99·20	100·53	97·4+	99·05	99·91	99·65
Specific Gravity	9·311	9·377	...	...	8·14	...	...
Analyst	Simpson	Mingaye	Rogers	McGeorge	Frenzel	Krusch	Carnot

Samples I. and II. were from the Australia Mine (Associated Gold Mines), III. from the Lake View Consols Mine, IV. from the Block 45 Mine.

Other determinations of the percentage of gold in this mineral gave 37·10 per cent. in a cleavable fragment (Krennerite?) from the Lake View Consols Mine, and 41·28 per cent. in a piece of the massive variety from the Australia Mine.

The presence of selenium in this mineral (as shown by analysis VI.) and also in other Kalgoorlie tellurides is not only

* P. Krusch Die Tellurerze Westaustraliens. Zeits. für Prakt. Geologie, 1901. Heft 6, s. 211. It is advisable to point out here some errors made in this paper with reference to the composition of the Kalgoorlie calaverite, coloradoite, and petzite, Rickard having misquoted an analysis made by myself and appearing as I. in Table III. of this Bulletin. Krusch has in quoting from Richard repeated this mistake, making my analysis appear as:—Gold, 41·56; silver, 0·65; tellurium, 57·79. Rickard also gives as the theoretical composition of coloradoite—mercury, 61·5; tellurium, 38·5; and as the theoretical composition of petzite—gold, 25·5; silver, 42·0; tellurium, 32·5. These figures Krusch has mistakenly quoted as those of actual analyses of Kalgoorlie minerals.

+ Also 2·1 per cent. of admixed arsenopyrite.

scientifically interesting but also of considerable practical importance. Some four years ago it was found at one of the leading cyanide works at Kalgoorlie that when the zinc slimes carrying the precipitated gold were purified by treatment with sulphuric acid, a very considerable amount of gold went into solution with the zinc and had in some cases been lost. This was undoubtedly due to the selenium in the ore being dissolved by the cyanide solution, precipitated with the gold in the zinc boxes and finally converted into selenious acid (a solvent of gold) by the sulphuric acid. This method of purification had, therefore, to be abandoned in favour of roasting the slimes with nitre in a muffle.

Experiments have shown that this mineral is unaffected by concentrated hydrochloric acid, but on heating up to strong fuming with concentrated sulphuric acid the tellurium goes into solution, colouring the acid crimson, and finally leaving a residue of pure gold. It is decomposed by concentrated nitric acid with the separation of spongy metallic gold, and dissolves in aqua regia leaving a faint residue of silver chloride.

Before the blow-pipe it fuses readily to a round globule. As the heating is continued the tellurium volatilises completely, leaving behind a button of gold, colouring the flame bright bluish-green, and giving a white incrustation and fumes. The white incrustation turns black when moistened with stannous chloride solution. In the open tube it melts and gives a strong white sublimate, which melts near the flame, and is yellow when hot and white when cold. In the closed tube it behaves similarly. Calaverite occurs with the other tellurides mentioned, in irregular masses, strings and veins in greenstone schists and other foliated rocks, as well as in the veins of quartz, calcite and other carbonates traversing them. In the transition zone it is often found to be covered on exposed faces by a thin layer of mustard gold, whilst in the oxidised zone all the tellurium has been removed leaving free gold only.

Goldschmidtite.—This mineral, described in the First Appendix to the Sixth Edition of Dana's System of Mineralogy, is of occasional occurrence at Kalgoorlie, having been several times described under the name of sylvanite, which it closely resembles. The following are analyses of this mineral:—

	I.	II.	III.
Gold, Au	28·55	36·95	29·85
Silver, Ag	9·76	8·30	9·18
Copper, Cu	·32	...	·15
Iron, Fe	·06	...	...
Nickel, Ni	·10	...	·10
Tellurium, Te	60·83	54·50	60·45
Selenium, Se	·20	...	...
Sulphur, S	·09	...	...
Totals	99·91	99·81	99·73
Analyst	Krusch	Higgin	Carnot

Analyses I. and III. correspond to the formula $(Au\ Ag)\ Te_2$, with $Au : Ag = 5 : 3$.

Petzite.—Complete descriptions of this mineral are to be found in the text books. It is essentially a telluride of gold and silver, having the formula $(AuAg)_2Te$, and black or steel-grey in colour. It is said to be common in the Kalgoorlie mines, but, as in outward appearance it is practically indistinguishable from kalgoorlite, coloradoite, or bournonite, all of which are associated with it, it is impossible to definitely confirm this statement. The following are analyses of Kalgoorlie specimens of this ore, several of which show notable amounts of mercury in addition to gold and silver :—

TABLE IV.—*Analyses of Kalgoorlie Petzite.*

	I.	II.	III.	IV.	V.	VI.
Gold, Au	24·33	24·64	24·62	24·16	23·42	23·58
Silver, Ag	40·70	40·47	40·55	41·22	41·37	43·31
Mercury, Hg ...	..	·29	...	2·00	2·26	·88
Copper, Cu ...	·10	...	...	·10	·16	·20
Iron, Fe	·07	...	...	...	...	Trace
Nickel, Ni	·08	...	...	...	...	...
Tellurium, Te ...	32·60	34·60	34·83	32·33	33·00	31·58
Selenium, Se ...	1·45	.	...	...	...	...
Sulphur, S	·26	...	...	...	...	...
Antimony, Sb ...	...	...	...	...	...	·30
Totals	99·59	100·00	100·00	99·81	100·21	99·85
Analyst	Krusch	Grace	Grace	Carnot	Carnot	Carnot

Kalgoorlite.—This mineral is only known at Kalgoorlie, where it was first recognised by Mr. E. F. Pittman.* The following is a description of its chief features :—Massive; brittle; fracture conchoidal to sub-conchoidal; specific gravity, 8·79; lustre, metallic brilliant; colour, black opaque; composition, subtelluride of gold, silver, and mercury; formula, $Au_2Ag_6HgTe_6$, requiring gold, 19·6 per cent.; silver, 32·3 per cent.; mercury, 10·0 per cent.; tellurium 38·1 per cent. The following is the original analysis made by J. C. H. Mingaye :—

Gold, Au	20·72
Silver, Ag	30·98
Copper, Cu	·05
Mercury, Hg	10·86
Tellurium, Te	(37·26)
Sulphur, S	·13
	100·00

A determination of the gold and silver made by the author on a sample from the Ivanhoe Mine gave :—

Gold, Au	19·4 per cent.
Silver, Ag	30·1 ,,

* Government Geologist of New South Wales.

Coolgardite.—This mineral was discovered by A. Carnot, and is, like kalgoorlite, peculiar to Kalgoorlie. It is steel-gray to yellow-grey in colour, is practically devoid of cleavage, and breaks with a conchoidal fracture. Its formula is $(AuAgHg)_2Te_3$, and it is, therefore, related to coloradoite (Hg_2Te_3) and melonite (Ni_2Te_3). The following are Carnot's analyses:—

	I.	II.	III.
Gold, Au	23·15	27·75	37·06
Silver, Ag	16·65	13·60	4·71
Mercury, Hg	3·10	3·70	3·70
Copper, Cu	·10	·25	·88
Iron, Fe	Trace	Trace	·90
Tellurium, Te	56·55	53·70	51·13
Antimony, Sb	·20	·15	1·20
Total	99·75	99·15	99·58

Other Auriferous Tellurides.—Two analyses of Kalgoorlie tellurides which have been published, one by Krusch, the other by Carnot, represent either minerals intermediate in character between petzite (M_2Te), kalgoorlite (M_3Te_2) and coolgardite (M_2Te_3), or mixtures of those minerals. The following are the analyses:—

Gold, Au	15·06	26·10
Silver, Ag	45·95	30·43
Mercury, Hg	...	·70
Copper, Cu	1·16	·60
Iron, Fe	·08	·40
Nickel, Ni	·06	...
Zinc, Zn	·04	...
Tellurium, Te	36·90	41·11
Sulphur, S	·45	...
Antimony, Sb	·12	·80
	99·82	100·14
Formula	M_5Te_3	M_4Te_3
Analyst	Krusch	Carnot

A specimen of native tellurium from Kalgoorlie was found to have the following composition:—

Gold, Au	2·40
Iron, Fe	Trace
Tellurium, Te	96·93
Sulphur, S	Trace
	99·33
Analyst...	R. W. E. McIvor

(3.) Compounds of Gold with other Elements.

Arsenical Compounds.—Krusch notes the occurrence at Kalgoorlie of auriferous Enargite (sulphide of arsenic and copper, Cu_3AsS_4) of the following composition :—

Gangue	.26
Gold, Au	·12
Silver, Ag	·22
Copper, Cu	41·69
Iron, Fe	4·76
Nickel, Ni	·15
Zinc, Zn	2·68
Lead, Pb	·10
Arsenic, As	16·87
Antimony, Sb	4·30
Tellurium, Te	·05
Sulphur, S	28·43
	99·63

Auriferous arsenical pyrites (sulphide of arsenic and iron, $FeAsS$) occurs in several parts of the State.*

Antimonial Compounds.—Stibnite (sulphide of antimony, Sb_2S_3) from Mallina, Pil., and Wiluna, E.M., which yielded no gold on amalgamation was found to assay high in that metal in both instances. The gold was probably present in combination with the antimony.

Bismuthic Compounds.—Some small fragments of native bismuth extracted from quartz from Burbanks and showing no signs of free gold under the microscope were found on assay to contain about one per cent. of that metal. Native bismuth from Yalgoo and Lawlers has also been shown to contain gold. The following are assays of a flinty ferruginous quartz, carrying native bismuth, from the former locality :—

	I.	II.
Gold, Au	79·05	69·25 ozs. per ton.
Silver, Ag	3·02	3·27 ,, ,, ,,
Bismuth, Bi	2·61	Trace per cent.

In the case of sample II. most of the metallic bismuth had been oxidised and leached out, leaving the gold in the form of fine dust congregated close to the places originally occupied by the bismuth.

(B.) Secondary Minerals associated with Gold.

The following list has been prepared of the secondary minerals which have been found in intimate association with gold in reefs

* See Table V., p. 20

and lodes. Quartz, pyrites, and limonite, being invariable concomitants, have been omitted from the list.

TABLE V.—*Secondary Minerals associated with Gold.*

Goldfield.	Locality.	Associated Minerals.
Kimberley ...	Hall's Creek ...	Galena, chalcopyrite, hæmatite, calcite, malachite
	Brockman's ...	Graphite, galena, calcite
	Ruby Creek ...	Graphite, arsenopyrite, hæmatite
	Mary River ...	Calcite
	Mount Dockerell ...	Galena
	Panton River ...	Galena
Pilbarra	Nullagine	Diamond,* chlorite
	Talga Talga ...	Chlorite
	Tambourah ...	Galena, chalcopyrite, malachite
	Bamboo Creek ...	Sericite
	Warrawoona ...	Galena
	Yandicoogina ...	Galena, blende, chalcopyrite, malachite
West Pilbarra ...	Mallina	Stibnite, cervantite
	Peewah	Stibnite
	Roebourne	Copper, malachite
Gascoyne ...	Bangemall ...	Pyrolusite
Ashburton ...	Hearn's Find ...	Chalcedony
	O'Grady's Creek ..	Chalcedony, pyrolusite
	Gorge Creek ...	Chalcopyrite, malachite
Peak Hill ...	Peak Hill	Sulphur, sericite, kaolin
	Horseshoe	Galena, malachite
Murchison ...	Nannine	Silver, galena
	Gabanintha ...	Malachite
	Cue	Chlorite
	Mount Magnet ...	Chalcedony, hæmatite, calcite
	Mulga Mulga ...	Stibnite, chalcopyrite
	Island	Gypsum
Yalgoo	Yalgoo	Bismuth, galena, bismutite
	Rothsay	Chalcocite, chalcopyrite, tenorite, malachite
	Pinyalling	Vanadinite
East Murchison	Wiluna	Stibnite, bournonite, cervantite
	Sir Samuel ...	Copper, chalcopyrite, malachite, azurite
	Lawlers	Bismuth, blende, bismutite
North Coolgardie	Mulline	Kaolin, vanadinite
	Menzies	Galena, kaolin
	Niagara	Arsenopyrite
	Mount Ida	Chalcopyrite
North-East Coolgardie	Kanowna	Asbolite, calcite, magnesite, kaolin
Broad Arrow ...	Bardoc	Chalcedony, hæmatite, calcite, epidote
	Paddington ...	Arsenopyrite

* 230 tons of ore treated in 1900 yielded 77·70 ozs. of gold and 25 small diamonds of unknown weight.

TABLE V.—*Secondary Minerals associated with Gold*—continued.

Goldfield.	Locality.	Associated Minerals.
East Coolgardie	Kalgoorlie–Boulder	Tellurium, kalgoorlite, coolgarlite, petzite, blende, coloradoite, chalcopyrite, löllingite, krennerite, calaverite, bournonite, pyrargyrite, proustite, enargite, fluorite, hæmatite, magnetite, rutile, asbolite, calcite, dolomite, magnesite, ankerite, siderite, malachite, sericite, fuchsite, chlorite, kaolin, gypsum, roscoelite
Coolgardie ...	Coolgardie	Copper, galena, blende, pyrrhotite, chalcopyrite, arsenopyrite, cuprite, calcite, dolomite, malachite azurite, chlorite, vanadinite gypsum, scheelite
	Burbanks	Bismuth, pyrrhotite, siderite, bismutite
	Red Hill	Cerargyrite, calcite, dolomite gypsum
	Bonnie Vale ...	Blende, arsenopyrite
Yilgarn	Southern Cross ...	Galena, pyrrhotite, chlorite, scheelite
	Knutsford	Chalcopyrite
Dundas	Norseman	Galena, blende, pyrrhotite, asbolite
	Dundas	Bismuth, bismutite
Phillips River ...	Ravensthorpe ...	Chalcocite, chalcopyrite, malachite, azurite
Donnybrook ...	Donnybrook ...	Chalcedony, siliceous sinter

(C.) GOLD MATRICES.

The auriferous ore deposits of the State fall naturally into two broad divisions :—

(1.) Veins, lodes or other deposits in which the concentration of the precious metal has been subsequent to the formation of the enclosing rock (primary deposits).

(2.) Deposits in which the gold has been concentrated by mechanical action contemporaneously with the formation of the rock itself (secondary deposits).

(1.) Primary Deposits.

The deposits in Class (1.) may be subdivided into :—

- (*a.*) Veins including stockworks.
- (*b.*) Dykes.
- (*c.*) Lode formations.
- (*d.*) Shallow impregnations of surface material.

They are found chiefly within the areas occupied by amphibolites and metamorphic rocks of various kinds, consisting largely of

hornblende and chlorite schists derived from amphibolites, but including also mica schists, slates, quartzites, etc.

(*a.*) *Veins.*—The gangue of most of these consists of quartz, and it is from quartz reefs that most of the gold of the more northern fields, as well as Coolgardie and Dundas, has been obtained. Veins of dolomite and other carbonates carrying gold have been worked at Red Hill (C.), Vosperton (N.E.C.), and Kalgoorlie (E.C.). The auriferous veins of Donnybrook are extremely interesting, consisting in places of porous silica, resembling siliceous sinter, either massive or forming skeletal crystals in the ordinary form of quartz. The only theory that has been advanced to account for this peculiar formation is that the silica was originally precipitated as an intimate mixture of the colloidal and crystalline forms, the former of which being more soluble in water has since been removed in solution, leaving behind a skeleton of crystalline silica.

Stockworks of quartz veins have yielded payable gold in Coolgardie, Bardoc, and Kalgoorlie, whilst fault breccias, which form the connecting link between this class and class (*c*) have been worked at Coolgardie, Menzies, and Mt. Magnet.

(*b.*) *Dykes* of felsite and acid porphyries, associated with the older basic schists, are occasionally found to carry payable gold in the solid rock, as well as in the stockworks which it frequently encloses. Instances of this form of deposit are known at Londonderry, Burbanks, and Bardoc.

(*c.*) *Lode Formations.*—The term "lode formation" is one that appears to be confined to West Australia, but is used here because no other name is available for this very definite class of deposits, except the extremely unsuitable one "composite (or compound) vein."* A lode formation may be defined as a more or less vertical zone of rock, usually continuous with the surrounding rock, and of similar origin, but distinct from it in carrying metallic ores disseminated through it in payable quantities, and, as a rule, characterised by strong foliation. Deposits of this nature are probably deep seated; at Kalgoorlie mining operations have already proved their persistence to 1,500ft. below the surface. The typical lode formations probably owe their origin to a shearing action having crushed and foliated portion of a rock mass in a certain definite direction, producing a more or less well-defined band of rock through which, by virtue of the foliation, mineral-bearing solutions or vapours can have free circulation. In consequence of this, mineral deposits are formed within the rock, usually, but not necessarily, extending over the whole of the foliated zone, but seldom beyond it, and having no definite boundaries horizontally or vertically other than those determined by the decrease of the assay value of the rock in any one direction to a point at which it ceases to pay the expenses of working.

*Louis' translation of Schmeisser's "zusammengesetzte Gange." The term "lode formation" conveniently includes the similarly derived deposits often separated under the terms "impregnations" and "disseminations."

The most notable development of deposits of this description is to be found at Boulder, the Southern portion of the Kalgoorlie belt. From there, something over two million ounces of gold have been taken in the last seven years. In this area the rocks consist mainly of amphibolites (altered in various ways, but largely into massive chlorite rock and chlorite schist), together with some smaller bodies of porphyrite, felsite, slate, and quartzite. A complete description (with analyses) of these rocks appears on another page. The lode formations consist almost entirely of vertical or steeply-inclined zones of chlorite schists, or foliated greenstone often passing insensibly into unaltered greenstone on either side, but sometimes showing an irregular boundary. They vary in width from 2 or 3 feet up to 80 feet, and carry disseminated grains of gold, calaverite, kalgoorlite, and other secondary minerals. The following are analyses of three samples of lode stuff from Boulder:—

		No. 206.	No. 1753.	No. 1732.
	Water, H_2O, hygroscopic	·40	·09	·42
	Do. H_2O, combined	·22	·30	1·34
Soluble in Aqua Regia.	Lime, CaO	6·09	6·33	·14
	Magnesia, MgO	3·02	3·56	·12
	Manganous oxide, MnO	Trace	·32	...
	Ferrous oxide, FeO	2·32	8·49	·87
	Ferric oxide, Fe_2O_3	1·54	·33	1·00
	Alumina, Al_2O_3	1·33	·31	·22
	Carbonic anhydride, CO_2	8·02	13·41	·02
	Copper, Cu	...	...	·50
	Iron, Fe	3·99	1·05	2·47
	Sulphur, S	4·42	1·20	2·96
	Tellurium, Te	Trace	*Nil*	...
Insoluble in Aqua Regia.	Lime, CaO	·31	·10	*Nil*
	Magnesia, MgO	1·16	Trace	Trace
	Manganous oxide, MnO	Trace	*Nil*	*Nil*
	Ferrous oxide, FeO	·31	·71	Trace
	Alumina, Al_2O_3	12·52	12·18	15·00
	Titanic oxide, TiO_2	·23	·14	·34
	Silica, SiO_2	51·27	46·94	70·25
	Potash, K_2O	2·37	2·57	1·28
	Soda, Na_2O	1·78	1·84	3·46
		101·30	99·87	100·39
Gold, ozs. per ton		9·636	Trace	1·688
Silver, ozs. per ton		6·371	*Nil*	·816
Specific Gravity		2·95	2·94	2·73
Analyst		E. S. Simpson	C. G. Gibson	E. S. Simpson

No. 206.—Lodestuff, 300ft. level, Lake View Consols Gold Mine.
No. 1753.— Do. 400ft. level, Ivanhoe Gold Mine.
No. 1732.— Do. Hannan's Paringa Gold Mine.

Nos. 206 and 1753 are typical of the lode-formations of the district, being grey or greenish-grey greenstone schists, whilst No. 1732 is of an exceptional character, being a dark grey foliated mudstone. The former are found altered near the surface into either a brown ferruginous clay-rock, often containing much sericite or gypsum or, where the leaching action of ground water has been more marked, into a pure white kaolin. A sample of brown weathered lodestuff from the 50ft. level, Great Boulder Perseverance Gold Mine, was found to have the following composition:—

No. 6.

	Water, H_2O, Hygroscopic	·73
	Do. Combined	5·95
Soluble in Hydrochloric Acid.	Lime, CaO	Trace
	Manganese dioxide, MnO_2	·97
	Ferrous oxide, FeO	1·60
	Ferric oxide, Fe_2O_3	36·29
	Alumina, Al_2O_3	3·12
	Sulphuric anhydride, SO_3	Trace
Insoluble.	Magnesia, MgO	Trace
	Ferrous oxide, FeO	Trace
	Alumina, Al_2O_3	11·48
	Silica, SiO_2	39·76
	Alkalis...	Not determined.
		99·90

Gold, ozs. per ton	5·116
Silver do.	1·733

Similar payable lode formations of greenstone schists occur at Kanowna, whilst at Peak Hill a notable amount of gold is derived from quartz schists and other foliated rocks. At Mt. Leonora and Norseman also similar deposits have yielded payable ore. To this class also are to be referred the ore bands of chalcedonic quartz and jasper, which contain payable gold in such widely separated localities as Horse Shoe, Black Flag, and Mt. Magnet. Bands of more or less foliated rock occurring in the walls of rich gold reefs are frequently found to be auriferous. Such instances are known at Coolgardie (chlorite schist and amphibolite), Bardoc (amphibolite), Donnybrook (sandstone), Kimberley district (slate).

The auriferous conglomerate beds of Nullagine (Pilbarra) are referable to this class, the gold in them being of secondary nature, and occurring in well defined bands. Three typical samples of these deposits were found to assay respectively 1·30, 2·05, and 5·70ozs. of gold per ton.

(*d.*) *Shallow Impregnations of Surface Material.*—The upper portions of the old rock surface immediately underlying the richer leads at Kanowna have been found to contain payable gold in many places, and have been worked out with the rock. The rock consists of decomposed porphyry and chloritic schists, and most, if not all, of the gold in it is in the form of fine scales on the joint planes, an evidence that the enrichment of the rock has been largely subsequent

to its weathering. The so-called "pug" of Kanowna, a bedded kaolin of comparatively recent age, overlying the coarse auriferous wash, is extremely rich in places, owing to the large development of minute crystals and flakes of secondary gold on joint planes. This class passes imperceptibly into the true original alluvial deposits.

(2.) Secondary Deposits.

The deposits in Class (2) embrace:—

(*a.*) Residuary soils and gravels.

(*b.*) Alluvial deposits.

(*a.*) *Residuary Soils and Gravels.*—In such districts as Kalgoorlie where the rainfall is very slight (averaging about five inches per annum), and where rich gold-bearing rocks outcrop on comparatively flat ground, the surface soil resulting from the decomposition *in situ* of these rocks is highly auriferous, a natural cause of concentration being found in the wind which would more readily remove the lighter constituents of the soil than the heavier gold. Much of the surface gold of Western Australia has been derived from deposits of this nature, especially at Boulder and Coolgardie. At the latter centre much of the so-called alluvial of Fly Flat was the weathered residue of auriferous felsite dykes.

These residuary deposits pass insensibly into—

(*b.*) *True Alluvial Deposits.*—These may be roughly divided into recent accumulations still in process of formation, and older deposits no longer being enriched by the addition of fresh gold-bearing material.

Examples of the former are to be found in every district where reef gold has been obtained, and in the interior of the State, where the rainfall is small, are seldom at any great distance from the parent ore body. The material of which these deposits are composed is generally a more or less ferruginous sandy clay, frequently containing much travertine. Of this nature are the more recent deposits of Cue, Wiluna, Bardoc, Kurnalpi, Kalgoorlie, and Coolgardie. On the Pilbarra and other Northern fields, where the rainfall at certain seasons is very heavy, a considerable quantity of gold is recovered from river sands and gravels of the usual type. The dry lakes of the interior, occupying as they do the lowest-lying portions of the country, have long been suspected of containing in their sandy beds material which would pay to treat on a large scale. Practically nothing has yet been done to settle the truth or otherwise of this suspicion.

The latter division of these deposits embraces those older alluviums which have within recent years been worked at Kanowna, Bulong, Broad Arrow, Boulder, Siberia, Kintore, Norseman, and Island (Lake Austin) amongst other places. At Kintore (*C.*) the gold occurs in a series of beds of sandstone, conglomerate, and kaolin, forming the remnants of an old river deposit on a granite

bedrock. At Kanowna the deposits, which within recent years have yielded about 200,000ozs. of gold, are of two distinct ages:—

(1.) An older siliceous conglomerate (cement) outcropping at the surface, and now quite vitreous from the development of secondary silica.

(2.) The newer deposits of the deep leads, consisting of a series of sands, gravels, clays, magnesian travertine, vitreous sandstone, and conglomerate, all of which carry payable gold.

SILVER.

The number of native compounds of silver hitherto recognisec in this State is very small. It has already been mentioned tha kalgoorlite, a telluride of gold, silver, and mercury, containing abou 30 per cent. of silver, petzite a similar compound containing 42 pe cent. of silver, and other tellurides carrying smaller proportions o this metal, occur in irregular masses in the lode formations of Kal goorlie. In the same deposits small strings of proustite (sulphid of arsenic and silver, with 65 per cent. of the latter, Ag_3AsS_3) anc pyrargyrite (sulphide of antimony and silver, with 60 per cent. o the latter, Ag_3SbS_3) are frequently visible in the unweathered ore whilst a specimen of ore (No. 1501) from the Lake View Consol G.M., in the Departmental Museum, shows a large mass of calaverit (telluride of gold), studded thickly in places with small crystals c both these minerals. The average Kalgoorlie ore contains abou one ounce of silver for every two ounces of gold, and very little o the former seems to be recovered in the treatment to which the or is subjected.

A small specimen of gold ore from Red Hill (C.), examine some years ago, was found to contain cerargyrite (chloride of silve with 75 per cent. silver). A sample of auriferous quartz fro Nannine shown to the writer before being sent to the Paris Exhib tion of 1900, contained a fragment of what appeared to be nati silver. Electrum (alloy of gold and silver), with 51 per cent. silver, has been recognised in ore from Donnybrook. This exhaus the list of silver minerals proper so far recorded.

The crude gold produced by the State during 1900 had a average fineness of 88·05, and contained therefore about 176,000oz of fine silver. Apart from this, no silver was produced in the Stat except a few ounces obtained in smelting copper ores from Geraldi and Ravensthorpe, and telluride ores from Kalgoorlie. A sample ore from Uaroo (Lyndon District) yielded on assay: copper, 29·8 per cent.; lead, 4·9 per cent.; silver, 29·55ozs. per ton; gold, trac

In the lead deposits of the State, especially of the North-Western portion of it, there is a source of silver which, up to the present, has hardly been touched. The following assays of argentiferous lead ores have been made in the department:—

TABLE VI.—*Assays of Argentiferous Lead Ores.*

Locality.	Nature of Ore.	Lead.	Silver.
		per cent.	ozs. per ton.
Panton River, Kimberley ...	Galena	70·0	26·60
Hall's Creek, Kimberley ...	Galena and quartz	52·2	11·80
Tambourah, Pilbarra ...	Cerussite, etc. ...	43·3	22·69
Do	do ...	60·1	88·31
Do	Galena	64·5	68·75
Do	do ...	68·8	75·07
Balla Balla, West Pilbarra	?	63·5	19·40
Do	?	23·8	13·80
Mallina, West Pilbarra ...	Galena	58·4	24·40
Mt. Edith, North-West ...	?	30·8	16·95
Uaroo, Ashburton	Cerussite ...	69·2	17·60
Horseshoe, Peak Hill ...	Galena and quartz	4·3	20·15
Yalgoo, Yalgoo	Galena and ferruginous quartz	14·9	20·65
Coolgardie, Coolgardie ...	Galena	78·6	143·10

Two further samples from Uaroo, assayed at the Fremantle Smelting Works, yielded: lead, 67·8 per cent.; silver, 16·1ozs. per ton; and lead, 67·3 per cent.; silver, 18·3ozs. per ton.

Other lead ores carrying a smaller proportion of silver are tabulated under "Lead," page 32.

MERCURY.

Mercury is only known to occur in one district in the State—viz., Kalgoorlie—where it is intimately associated with gold ores. Gold amalgam, kalgoorlite and coolgardite (both tellurides of gold, silver, and mercury) and coloradoite (telluride of mercury, Hg_2Te_3 ?) all occur in the foliated chloritic lode-formations, the last-named very freely and in large masses in some of the mines. Portion of a large specimen of coloradoite from the "Australia" lease, Boulder, was found to have the following composition:—

Mercury, Hg	50·40
Gold, Au	Trace
Silver, Ag	·12
Tellurium, Te	49·48
	100·00
Specific Gravity	9·21

Since Kalgoorlie is the only locality in the world where coloradoite has been found in large pure masses, this analysis is of more than usual interest. The formula for the mineral calculated from these figures is Hg_2Te_3, requiring: mercury, 51·7 per cent.; tellurium, 48·3 per cent. The previously-accepted formula for coloradoite, based upon analyses of small and impure specimens, was HgTe, requiring: mercury, 61·6 per cent; tellurium, 38·4 per cent.—a formula which recalculation has shown to differ considerably from the results of all previous analyses, the mean of ten quoted by Dana being: mercury, 54·7 per cent; tellurium, 45·3 per cent.

The chief characteristics of this mineral are as follow:—Massive; fracture, sub-conchoidal; slightly sectile; hardness, 3; specific gravity, 9·2; lustre, metallic brilliant; colour, black to dark lead grey; streak, dull black.

On charcoal before the blowpipe fuses readily without decrepitation, entirely volatile, giving white fumes, and an incrustation which is white on the inner side, bluish-white on the outer; in open and closed tubes gives two distinct sublimates, one white and easily fusible of tellurous oxide, the other of metallic mercury.

On warming with 36 E sulphuric acid, the mineral is slightly acted upon, giving a crimson solution: insoluble in hydrochloric acid: decomposed by 17 E nitric acid, leaving a very slight residue of metallic gold: entirely soluble in *aqua regia*. The solution of the mineral in nitric acid gives reactions for mercury and tellurium.

It is well to note that ores containing this mineral cannot be assayed for mercury in the usual way by heating with lime, as part at least of the tellurium is in this way volatilised with the metal. The addition of crushed hæmatite to the lime prevents this however.

COPPER.

Copper ores are plentifully distributed throughout the State, more especially in the North-West; but owing to the fact that they usually carry little or no gold or silver, have only been worked in a few localities, notably Whim Creek, Northampton, Murrin Murrin, and Ravensthorpe. In view of the fact that small quantities of copper-bearing minerals so frequently accompany the gold ores of the State, as shown in Table V., it appears strange that the precious metals do not occur in larger quantities in the copper ores proper.

The only analysis of a copper mineral available is that of enargite from Kalgoorlie, given on page 19.

A list of localities where copper minerals occur is given in Part III., to which must be added those already published in Bulletin IV. of this Survey. The following is a list of localities where workable deposits of copper are known to exist :—

Tambourah, Pil.; Whim Creek, Egina, Hong Kong, Croydon, Roebourne, W.P.; Red Hill, Uaroo, N.W.; Day Dawn, M.; Geraldine, Northampton, Yandanooka, Arrino, S.W.; Murrin Murrin, M.M.; Muline, N.C.; Arrow Lake, B.A.; Boorara, E.C.; Ravensthorpe, Harbour View, P.R.

Very little has been done in the examination of the copper deposits of the State, but so far they seem to be of two kinds, viz.:—

(1.) True lodes.

(2.) Impregnations and stockworks.

(1.) *True Lodes.*—To this class apparently belong the majority of the workable deposits, ores from which have yielded on assay the results given in Table VII.

TABLE VII.—*Assays of Copper Ores from Lodes.*

Locality.	Description of Ore.	Copper.	Lead.	Gold.	Silver.
		per cent.	per cent.	ozs. per ton.	ozs. per ton.
Whim Creek ...	Malachite and cuprite	43·2	...	Trace	1·45
Croydon ...	Blende and chalcocite	56·17	...	Trace	2·60
Do. ...	do.	55·8	...	...	...
Do. ...	do.	61·2	...	...	...
Do. ...	do. partly oxidised	45·6	...	...	...
Red Hill ...	Malachite, cuprite, quartz	24·90	...	Trace	2·45
Do. ...	do.	18·68	...	Trace	Trace
Do. ...	do.	17·20	...	*Nil*	*Nil*
Do. ...	do.	46·24	...	*Nil*	*Nil*
Do. ...	do.	35·76	...	*Nil*	*Nil*
Do. ...	do.	3·80	40·6	·040	1·05
Uaroo	Malachite, cerussite, etc.	29·88	4·9	Trace	29·55
Do. ...	Malachite, cuprite, iron oxides, & quartz	25·14	...	Trace	1·63
Do. ...	do.	5·71	...	*Nil*	·41
Do. ...	do.	39·70	...	*Nil*	*Nil*
Do. ...	do.	9·21	...	*Nil*	Trace
Belele Station ...	Cupriferous quartz...	2·81	...	·12	·70
Gorge Creek ...	do.	·87	...	1·427	2·29
Northampton ...	Malachite, iron oxides, etc.	18·63	...	Trace	2·29
Do. ...	do.	15·08	8·8	*Nil*	*Nil*

TABLE VII.—*Assays of Copper Ores from Lodes*—continued.

Locality.	Description of Ore.	Copper.	Lead.	Gold.	Silver.
		per cent.	per cent.	ozs. per ton.	ozs. per ton.
Northampton ...	Malachite iron oxide, etc.	14·48	...	*Nil*	*Nil*
Do. ...	do.	31·94	...	Trace	2·45
Do. ...	do.	37·85	...	...	...
Do. ...	Cupriferous gossan...	8·08	...	*Nil*	·87
Do. ...	Quartz, chalcopyrite, and galena	5·34	8·6	*Nil*	*Nil*
Wongan Hills ...	Cupriferous gossan ..	16·36	*Nil*	*Nil*	...
Do. ...	do.	9·12	...	...	...
Do. ...	Quartz and malachite	8·16	*Nil*	Trace	...
Murrin Murrin	Chalcocite	47·70	...	...	...
Do. ...	Cuprite, malachite, etc.	45·18	...	...	...
Serpentine ...	Pyritous quartz ...	3·75	*Nil*	*Nil*	*Nil*
Ravensthorpe ...	Malachite, cuprite, etc.	26·58	*Nil*	·32	1·30
Do. ...	do.	24·67	*Nil*	Trace	2·29
Do. ...	Quartz and malachite	11·85	*Nil*	·98	...
Do. ...	Quartz & chalcopyrite	17·83	*Nil*	·08	...
Do. ...	Malachite, chalcocite, etc.	30·48	*Nil*	·36	·95
Do. ...	do.	27·26	*Nil*	·16	1·45
Do. ...	do.	27·72	*Nil*	·08	2·50
Do. ...	do.	42·97	*Nil*	·08	·15
Do. ...	do.	38·43	*Nil*	·20	5·85
Do. ...	do.	24·60	*Nil*	·04	5·45
Do. ...	do.	26·18	*Nil*	·04	2·10
Do. ...	Chalcopyrite ...	26·18	*Nil*	Trace	1·30
Do. ...	Malachite, chalcocite, etc.	32·70	*Nil*	·49	1·45
Do. ...	do.	26·48	*Nil*	·32	1·95
Do. ...	do.	33·10	*Nil*	·04	·30
Do. ...	do.	38·73	*Nil*	·08	2·25
Do. ...	Pyrites & chalcopyrite	1·98	*Nil*	Trace	·95
Do. ...	Malachite, chalcocite, etc.	33·49	*Nil*	Trace	2·45

(2.) *Impregnations and Stockworks.*—The most important deposits of this class appear to be found in the Yandanooka Mineral District, where there are several beds of mica schist and porous sandstone carrying malachite, with occasionally a little azurite or cuprite. The ores average 10 to 12 per cent., are highly siliceous, and are not apparently readily concentrated. The copper minerals occur both as the cementing material of the rock and also in stockworks.

At Kalgoorlie bournonite, enargite, and chalcopyrite occasionally occur in the lode-formations below water level, whilst malachite was observed in one instance in the oxidised ore.

The following table contains all the available assays of ores of this class:—

TABLE VIII.—*Assays of Copper Ore from Impregnations and Stockworks.*

Locality.	Description of Ore.	Copper.	Gold.	Silver.
		per cent.	ozs. per ton.	ozs. per ton.
Yandanooka ...	Sandstone with malachite ...	9·72	...	...
Do. ...	do. do. ...	9·89	...	...
Do. ...	do. do. ...	22·77	...	...
Do. ...	Mica schist with malachite, etc.	11·80	Trace	1·15
Do. ...	Mica schist with malachite, etc.	57·90	Trace	Trace
Do. ...	Mica schist with malachite, etc.	29·00	Trace	Trace
Do. ...	Mica schist with malachite, etc.	20·90	*Nil*	*Nil*
Kalgoorlie ...	Oxidised ore with malachite	2·27	...	...
Do. ...	Foliated sandstone with chalcopyrite, etc.	·50	1·69	·82

LEAD.

The commercially important lead ores of the State are to a large extent closely associated with copper ores, as, for example, in the Northampton district. The lodes are mainly composed of cerussite (carbonate of lead, $PbCO_3$) at the surface and galena (sulphide of lead, PbS) below the water level, accompanied by more or less quartz and other gangue minerals. Anglesite (sulphate of lead, $PbSO_4$) occurs freely at Gorge Creek, Ashburton; and jamesonite (sulphantimonide of lead, $Pb_2Sb_2S_5$) at Mt. de Courcy, North-West; whilst fine specimens of crystallised pyromorphite (chlorophosphate of lead, $PbCl_2 3Pb_3P_2O_8$) have been obtained from the Geraldine Mine, on the Murchison River.

Small quantities of galena are frequently found to characterise the richer portions of gold reefs, notably at Menzies, Coolgardie, and Norseman; whilst small lemon-yellow crystals of the rare mineral vanadinite (chlorovanadate of lead, $PbCl_2.3Pb_3V_2O_8$) are found closely associated with gold in the oxidised ores of Pinyalling, Mulline, and Coolgardie.

A list of localities in which compounds of lead have been found is given in Part III. Lead ores have only been worked so far at Uaroo, Geraldine, Northampton, Oakagee, Narra Tarra, and Jarrahdale. Most of these ores, as well as those in many other parts of the State, are handicapped by not containing sufficient silver to pay for its extraction. A table of assays of argentiferous lead ores appears on a previous page. The following table contains the results of assays of these as well as other ores of lead :—

TABLE IX.—*Assays of Lead Ores.*

Locality.	Description of Ore.	Lead.	Copper.	Gold.	Silver.
		per cent.	per cent.	ozs. per ton.	ozs. per ton.
Panton River, Kimberley	Galena	70·0	*Nil*	*Nil*	26·60
Hall's Creek, Kimberley...	Galena and quartz	52·2	...	*Nil*	11·80
Tambourah, Pilbarra ...	Cerussite, etc. ...	43·3	*Nil*	·736	22·69
Do. do. ...	do. ...	60·1	*Nil*	*Nil*	88·31
Do. do. ...	Galena	64·5	*Nil*	Trace	68·75
Do. do. ...	do.	68·8	*Nil*	Trace	75·07
Andover, West Pilbarra ...	Galena and quartz	52·5	*Nil*	·040	2·10
Balla Balla, West Pilbarra	?	63·5	·10	Trace	19·40
Do. do.	?	23·8	1·47	Trace	13·80
Mallina, West Pilbarra ...	Galena	58·4	...	Trace	24·40
Mt. de Courcy, Ashburton	do.	75·0	*Nil*	*Nil*	9·95
Do. do.	do.	74·2	*Nil*	*Nil*	2·45
Mt. Edith, Ashburton ...	?	63·9	*Nil*	Trace	2·70
Do. do. ...	?	30·8	Trace	*Nil*	16·95
Mt. Stewart, Ashburton ...	?	40·6	3·80	·040	1·05
Uaroo, Ashburton ...	Cerussite, etc. ...	25·7	*Nil*	Trace	1·55
Do. do. ...	do. ...	69·2	·86	·040	17·60
Do. do. ...	do. ...	23·5	*Nil*	Trace	·80
Yannery River, North-West	Galena	73·0	Trace	·040	5·80
Do. do.	do.	69·6	1·30	·014	6·80
Gorge Creek, Ashburton...	Cerussite, etc. ...	52·8	·65	·162	8·62
Do. do.	do. ...	55·3	·83	·064	4·37
Geraldine, North-West ...	Pyromorphite ...	62·5	*Nil*	*Nil*	*Nil*
Northampton, South-West	Galena	70·3	...	*Nil*	·26
Narra Tarra, South-West	Massive cerussite	66·9	*Nil*	Trace	·25
Yalgoo, Yalgoo	Galena and ferruginous quartz	14·9	*Nil*	1·850	20·65
Coolgardie, Coolgardie ...	Galena	78·6	*Nil*	*Nil*	143·10

TIN.

The only ore of tin hitherto recognised in the State is the oxide, cassiterite, which has been worked for some years at Greenbushes, in the South-West, and in the vicinity of Marble Bar (Pilbarra), chiefly at the Shaw Tinfields, on Coglegong Creek, to the South-West, and the Moolyella Tinfields, on Brockman's and other

creeks, to the East. Cassiterite has also been reported on good authority to occur on the Thomas River, Gascoyne Goldfields, and at the heads of the Bow and Lennard Rivers, Kimberley District.

Pure tin oxide contains 78 per cent. of the metal, but the native compound invariably contains more or less of the oxides of other metals, with the result that it seldom assays over 74 per cent. of the metal. The Pilbarra cassiterite, which is dark brown in colour, would appear to average 70 per cent.; that from Greenbushes, which is quite black, slightly less.

The mode of occurrence of tin stone is as follows:—

Greenbushes District.

(1.) *Stanniferous impregnations.*—These consist of irregular bands of foliated granite, or greisen, assays of bulk samples of which have yielded ·55 per cent., 1·09 per cent., 1·79 per cent., and 3·46 per cent. of metallic tin. The associated minerals are quartz, muscovite, orthoclase, tourmaline, garnet, and zircon.

(2.) *Stanniferous dykes,*—These consist of schorlrock, carrying a small percentage of tin. The associated minerals are quartz, tourmaline, orthoclase, and mica.

(3.) *Alluvial deposits.*—These are the most important and vary very largely in nature, ranging from an extremely hard ferruginous conglomerate of a stiff clay, or loose sand or gravel. The tinstone in the first-named is often extremely coarse, but more generally one-tenth of an inch or less in diameter, whilst that in the softer material is almost uniformly fine. Assays of ten samples of this class of ore varied from ·9 per cent. up to 33·3 per cent. of the metal, the average being 10·1 per cent. The associated minerals are quartz, kaolin, limonite, ilmenite, tourmaline, tantalite, stibiotantalite, garnet, zircon, gold, magnetite, rutile, and topaz. In a sample of partly-dressed ore from Sinclair's Claim, in Spring Gully, ten small grains of metallic tin were found. These are probably of natural origin, perhaps reduced from surface ore during bush fires. No wolfram or scheelite has been detected in the ore: the mineral, once thought to be the latter, having proved in every case to be stibiotantalite. This mineral (a tantalite of antimony) and tantalite are of the greatest interest to the miners and smelters, since it is impossible to separate them from the tin stone by dressing, their specific gravities being practically identical. They have therefore to be smelted with the tin ore, and by contaminating the smelted tin with antimony, etc., seriously affect the purity and value of it. Owing principally to the presence of these two minerals—descriptions of which appear on page 42—the dressed ore from the alluvial claims has been found to be very variable in richness, ranging from a trace only of tin up to 72 per cent. A

sample of dressed ore containing considerable quantities of both of these minerals was analysed with the following results:—

Loss on ignition	·22
Tin dioxide, SnO_2	55·14
Titanic oxide, TiO_2	·67
Silica, SiO_2	1·61
Ferric oxide, Fe_2O_3	4·11
Alumina, Al_2O_3	·42
Manganese protoxide, MnO	1·61
Lime, CaO	·69
Magnesia, MgO	·39
Antimony trioxide, Sb_2O_3	13·13
Bismuth trioxide, Bi_2O_3	Trace
Tantalic oxide, Ta_2O_5	19·85
Niobic oxide, Nb_2O_5	3·56
	101·40

(4.) *Residuary deposits.*—These are either lateritic ironstones or sands, clays, etc., derived from the decomposition *in situ* of igneous rocks. They are frequently stanniferous. The chief minerals accompanying the tin are limonite, quartz, tourmaline, clay, and mica.

Marble Bar District.

(1.) *Stanniferous granite.*—At Brockman's Creek some tin ore has been obtained from a granite composed mainly of quartz and granular felspar.

(2.) *Alluvial Deposits.*—Most of the tin from this district has been derived from river sands and gravels. The only minerals observed in association with it are quartz and garnets. Gadolinite occurs in the adjacent granite at Coglegong Creek, and was at first mistaken by the prospectors for tinstone.

Silicates containing lithium and fluorine are so frequently associated with tin ores that it is interesting to note that topaz and lepidolite occur in large quantities at the mica mine near Londonderry; and lepidolite, tourmaline, and spodumene near Ravensthorpe. Tin ore has not up to the present been detected at either of these localities, though the presence of these minerals would point to the probability of its occurrence there.

IRON.

Natural compounds of iron are found plentifully in every region of the globe, but the main interest centres in such as occur in sufficiently large and pure bodies as to be available as a source of the metal, or in a lesser degree as a flux to be used in smelting lead

and other metals. Such deposits are disseminated over a wide area in this State, but are at present practically neglected, 12,000 tons only being raised in 1900, all of which was used as flux.

The deposits so far examined fall into four natural classes, viz.:—

(1.) Iron-bearing schists.
(2.) Bog ores.
(3.) "Laterite" ores.
(4.) Magnetic segregation ores.

(1.) *Iron-bearing Schists.*—These important ores are developed most extensively in the watershed of the Murchison River, more especially between 25deg. and 28deg. of South lat., and 116deg. and 119deg. East long. The most important localities are Horseshoe, Peak Hill, Mt. Gould, and Mt. No Name, Peak Hill; and Mt. Hale, Well Range (Wilgi-Mia), Munara Hills, and Mt. Narryer, Murchison. Less important deposits occur at Marble Bar, Pilbarra; Kilalo Well, Murchison; Wiluna, Mt. Townsend, and Mt. Marion, East Murchison; Bardoc, Broad Arrow; Mt. Jackson, Yilgarn; and Jennapullin, Blackboy Hill, and Greenhills, Avon district.

The deposits consist of highly-inclined beds, bands, and lenses of almost pure hæmatite (occasionally magnetite), or of admixtures in all proportions of hæmatite and quartz, interstratified with quartzites, quartz-schists, and other metamorphic rocks. At the surface the hæmatite is frequently found altered to limonite, though at Mt. Hale huge monoliths of pure hæmatite stand out on the flanks of the hill.*

The following are analyses by Dr. F. S. Earp of two ores of this description:—

	No. 338, Mt. Narryer.	No. 342, Mt. Hale.
Water, H_2O, etc.	4·82	1·08
Alumina, Al_2O_3	·60	·94
Manganese sesquioxide, Mn_2O_3	Trace	·55
Iron peroxide, Fe_2O_3	82·07	92·66
Iron protoxide, FeO	Trace	·97
Lime, CaO	3·32	·11
Magnesia, MgO	*Nil*	·55
Titanium dioxide, TiO_2	·53	1·09
Silica, SiO_2	9·33	3·14
Sulphuric anhydride, SO_3	·32	·09
Phosphoric anhydride, P_2O_5	Trace	·17
	100·99	101·35

* For a complete geological description of these deposits *vide* The Mineral Wealth of Western Australia. A. Gibb Maitland, Perth: By Authority: 1900, p. 98.

The following assays have also been made of similar ores :—

TABLE X.—*Assays of Iron-bearing Schists.*

Locality.	Description of Ore.	Metallic Iron.	Silica.	Water hygro-scopic.	Water com-bined.
		per cent.	per cent.	per cent.	per cent.
Mt. No Name, Peak Hill	Banded limonite ...	50·33	7·30	·38	11·45
Munara Hills, Murchison	Massive hæmatite	63·7	?	?	?
Mt. Hale, Murchison	Do. ...	65·62	*vide*	analysis	above
Wilgi Mia, Murchison	Do. ...	61·91	1·13	·13	3·97
Do. ...	Hard red "Wilgi"*	34·17	21·93	1·11	11·51
Wiluna, East Murchison	Argillaceous limonite	35·5	?	?	?
Mt. Narryer, North-West	Hæmatite quartz schist	57·45	*vide*	analysis	above
Mt. Jackson, Yilgarn	Fibrous limonite ...	60·20	1·62	·39	14·79
Bardoc, Broad Arrow	Siliceous hæmatite	55·5	?	?	?

* *i.e.* Native war-paint.

2. *Bog Iron Ores.*—Soft porous deposits of hydrated oxide of iron of comparatively recent formation are known at various points along the Southern and Western coast line. On the Eastern side of Herdsman's Lake, a few miles to the North of Perth, a deposit of this ore occupies part of what was once an extended portion of the lake bed, whilst close by its formation can be studied in a small creek bed, the iron being first precipitated as a yellow slime which settles to the bottom with more or less vegetable matter, etc., and cakes on the creek drying up.

Two samples only of this class of ore have been examined, with the following results :—

	2582 Herdsman's Lake.	2341 Wanneroo.
	%	%
Water lost at 100°	3·17	...
Water and Organic matter lost at a red heat	11·93	...
Metallic Iron	51·75	48·61
Silica	2·82	8·52

3. "*Laterite*" *Ores.*—These, with the gravels resulting from their denudation, are the most widely-distributed ores in the State, but are unfortunately the most erratic in quality, varying from a ferruginous bauxite or claystone to an almost pure limonite or turgite. The structure is sometimes massive and almost homogeneous, but is more frequently pisolitic or nodular, in which case the concretions are richer than the interstitial matter. Occasionally

the ore is cellular and streaky in colour, whilst still more rarely it appears brecciated, the angular fragments then consisting of almost pure hæmatite or limonite.

For these ores "the Indian term Laterite Ore, or the *Roche a Ravets* of French Guiana (with which the deposits are comparable) would be appropriate."* They are invariably found as superficial deposits overlying granite, diorite, or amphibolite, or choloritic schists derived from them. They are most largely developed on the caps of hills or ranges, but in many cases follow down the sides of the hills parallel to the undulations of the bed-rock, from which they are not separated by any hard-and-fast line. In depth they pass gradually into such highly ferruginous rocks as the diorites of the Darling Ranges or the amphibolites and chloritic schists of the interior. At Kalgoorlie cappings of very rich laterite occur on some of the hills, underlaid by clays now poor in iron, from which the iron was originally derived, for it represents the result of decomposition *in situ* of highly ferruginous amphibolites. At Darlington and elsewhere they are found to overlie granite as well as diorite or other basic rocks, but never far from the latter. They can in every case probably be accounted for by the concentration of the ferric oxide resulting from the surface decomposition of rocks rich in iron.

The following are assays of ores of this description: —

TABLE XI.—*Assays of Laterite Iron Ores.*

Locality.	Description of Ore.	Metallic Iron.	Silica.	Water Hygroscopic.	Water, Combined.
		%	%	%	%
Mt. Baker, South-West	Nodular laterite ...	51·33	4·44	?	?
Do. do.	Do. ...	50·54	5·49	?	?
Darling Range, do.	Do. ...	34·73	19·44	?	?
Do. do.	Do. ...	45·00	9·88	?	?
Do. do.	Do. ...	41·60	11·33	?	?
Do. do.	Do. ...	59·63	1·59	?	?
Do. do.	Do. ...	52·57	?	?	?
Serpentine, do.	Do. ...	29·95	9·71	·81	14·26
Greenbushes, do.	Turgite nodule ...	62·47	?	?	?
Do. do.	Laterite	52·43	(1·52)†	?	?
Do. do.	Loose pebbles from laterite	38·88	(23·26)†	?	?
Murrin Murrin, Mt. Margaret	Compact ironstone	52·55	2·55	·57	9·00
Kalgoorlie, East Coolgardie	Dark, slightly cellular, laterite ...	57·63	1·53	·52	8·10
Kalgoorlie, East Coolgardie	Mottled laterite ...	47·42	4·07	·63	10·84
Coolgardie, Coolgardie	Cellular laterite ...	25·13	?	?	?

* A. Gibb Maitland. The Mineral Wealth of Western Australia. Perth: By Authority: 1900, p. 91.

† Total insoluble matter.

4. *Magnetic Segregation Ores.*—Segregations of very pure magnetite have been found in the ferruginous dyke rocks (diorites, etc.) of the Darling Ranges at Serpentine and Collie Rivers. A sample from the latter locality yielded, on assay, 64·48 per cent. of iron. Similar deposits exist in the neighbourhood of Ravensthorpe, but their extent is unknown.

ALUMINIUM.

Bauxite and other hydrated oxides of aluminium, which form the chief sources of the metal, are probably of frequent occurrence in the deposits of laterite referred to under "Iron" and "Rocks of the Darling Ranges." It was first detected in these by the author when examining some specimens from the Wongan Hills in the spring of 1901. A subsequent examination of some heaps of gravel used for road-making in Perth pointed to its existence in the Darling Ranges, ample confirmation of which was obtained by a visit to the gravel pits at Mahogany Creek and Smith's Mill. The number of localities where this ore occurs will doubtless be found to be considerable when a more careful examination of the laterites is undertaken.

The laterites of Western Australia consist largely of hydrated oxide of iron, some deposits of excellent iron ore being known amongst them. Up till recently the chief additional constituent was thought to be clay, and the lighter coloured varieties were thought to contain a large percentage of that mineral. A sample, however, of mottled rock (G.S.M. 997) from Wongan Hills, varying in colour from reddish-brown to yellow, and slightly cellular in structure, was found to have the following composition:—

Water, H_2O, Hygroscopic	·58
,, ,, Combined	26·44
Alumina, Al_2O_3	44·66
Ferric oxide, Fe_2O_3	19·08
Lime CaO and Magnesia MgO	Trace
Titanic oxide, TiO_2	3·10
Silica, SiO_2	5·96
Sulphuric anhydride, SO_3	·18
Phosphoric anhydride, P_2O_5	Trace
	100·00
Specific gravity	2·56

This analysis proved that after the ferric oxide the next most important constituent of this rock was bauxite ($Al_2O_3 . 2H_2O$) and not clay, this latter being almost absent.

Plate IV.—Bauxite Deposit in face of Gravel Pit, Smith's Mill.

A sample (G.S.M. 3148) of light yellow nodular laterite broken from the lower portion of the hard surface bed, seen in Plate IV., gave the following results on analysis:—

Water, H_2O, Hygroscopic	·58
,, ,, Combined	24·79
Alumina, Al_2O_3	46·70
Ferric oxide, Fe_2O_3	10·02
Lime, CaO	Trace
Magnesia, MgO	Trace
Phosphoric anhydride, P_2O_5	Trace
Titanic oxide, TiO_2	·59
Silica, SiO_2	17·17
	99·95
Specific gravity	2·44

The silica in this sample was almost all present in the form of free quartz.

The formation of hydrated oxides of iron and alumina in these deposits appears to be due to the decomposition *in situ* of crystalline rocks by water carrying carbonic acid in solution. Both iron and alumina go into solution, the former as carbonate, the latter as hydrate, and are precipitated at or near the surface of the ground when the water dries out of the rock. Were free oxide of alumina as easy of detection as free oxide of iron is, it would probably be found everywhere to be as common a product of the decomposition of rocks as the latter is known to be.

NICKEL AND COBALT.

No ores of nickel have yet been discovered in this State other than slightly nickeliferous asbolites, although serpentinous rocks, their usual matrix, are comparatively abundant. Pyrrhotite (sulphide of iron, Fe_7S_8) is an important source of nickel in Canada and Scandinavia, but, though this mineral is abundant in many of our sulphide gold ores, notably in Fraser's Mine at Southern Cross, in no instance has much nickel been detected in it.

Of cobalt ores, asbolite (oxide of manganese, cobalt, etc.) has alone been recognised. This mineral occurs abundantly in parts of the deep leads at Kanowna, principally in the "pug" or bedded kaolin, and in the underlying much-weathered chlorite schists, from which it has doubtless been originally derived. It is either so thoroughly intermingled with the clay as to be inseparable from it, or else is found in lumps or lining vughs in a soft mammilated form, with a bright grey metallic lustre. It occurs also in the nodules of magnesite found at the junction of the "pug" and the adjacent

schists, and is frequently studded with minute crystals of gold. A sample of "pug" carrying asbolite was found to assay:

Cobalt	7·56 per cent.
Copper	·02 per cent.

A similar mineral occurs at Kalgoorlie in veins and impregnations in the oxidised portions of the lodes. A mixture of asbolite and clay from the decomposed schist at the 100ft. level of the Golden Horseshoe Mine assayed:

Cobalt	3·29 per cent.
Copper	·18 per cent.
Gold	·162 ozs. per ton
Insoluble Gangue	28·48 per cent.

In the Departmental Museum there is a small sample of auriferous quartz from Norseman which is coated with asbolite. No assays of it have been made.

ZINC.

Zinc blende (sulphide of zinc, ZnS) is known to occur in many portions of the State, being frequently found in small quantities in association with gold, and in many mines affording a visible indication of rich shoots of ore. More extensive deposits occur in the lead-bearing lodes of Northampton and the copper-bearing lodes of Croydon. Owing, however, to the small intrinsic value of zinc ores in Australia, no samples have ever been sent in to the laboratory for assay. The following analysis of a massive dark brown sample of blende (G.S.M. 3,015) collected from the dump of the Nooka Mine at Northampton is interesting chiefly because of the high percentage of cadmium shown therein:

Zinc, Zn	59·04
Cadmium, Cd	5·78
Iron, Fe	2·08
Lead, Pb	·37
Sulphur, S	32·66
	99·93
Specific gravity	4·07

Analyst, C. C. Williams.

ANTIMONY AND BISMUTH.

Ores of antimony are known to exist at Mallina and Peewah (West Pilbarra) and Wiluna (East Murchison), in each case consisting of stibnite (sulphide of antimony, Sb_2S_3) with cervantite

(Sb_2O_4) and other oxides nearer the surface. These ores carry both gold and silver, as shown by the following assays :—

TABLE XII.—*Assays of Antimony Ores.*

Locality.	Description of Ore.	Antimony.	Gold.	Silver.
		per cent.	Ozs. per ton.	Ozs. per ton.
Mallina	Stibnite and quartz ...	30·8	6·70	1·80
Do.	do. do. ...	29·7	Trace light	...
Do.	do. do. ...	14·9	1·06	...
Wiluna	Stibnite, cervantite, etc....	56·0	·65	·25
Do.	Cervantite, etc.	58·5	·32	·50

Small quantities of bournonite (sulphantimonide of copper and lead, $PbCuSbS_3$) and proustite (sulphantimonide of silver, Ag_3SbS_3) are scattered through the telluride ores of Kalgoorlie. A new mineral species, stibiotantalite (tantalo-niobate of antimony, $Sb(Ta.Nb)\,O_4$) accompanies the stream tin ores of Greenbushes; a complete description of it will be found under the heading "Rare Metals."

Small quantities of native bismuth and bismuth carbonate occur in some gold ores in the State. A sample of flinty ferruginous quartz from Yalgoo carrying both these minerals proved on assay to contain :—

Bismuth	2·61 per cent.
Gold	79·05ozs. per ton.
Silver	3·02ozs. per ton.

The demand for this metal being at present so limited no attempt has been made to save it, although by concentrating such an ore as that quoted a considerable amount of the metal could be recovered.

RARE METALS.

Considerable public interest is often taken in the occurrence of the rarer metals, largely on account of the very high prices quoted for their compounds. It should be remembered that the application of these metals in the arts is very restricted, and that it is only whilst their total production is so small that it can be expressed in pounds that a high price per lb. will be paid for them. Immediately any of them are produced in hundredweights or tons, a corresponding drop in values must be expected.

VANADIUM.—Vanadinite (chloro-vanadate of lead, $PbCl_2.3Pb_3V_2O_8$), which contains 19·4 per cent. of vanadium pentoxide,

occurs in small yellow crystals in auriferous quartz at Pinyalling, Mulline, and Coolgardie. Roscoelite or vanadium mica (hydrous silicate of vanadium, aluminium, etc.) has been recognised at Kalgoorlie. A sample of it taken from an auriferous lode was analysed by F. C. Knight, with the following result:—

Vanadium trioxide, V_2O_3	27·11
Alumina, Al_2O_3	9·95
Lime, CaO	1·43
Magnesia, MgO	1·51
Potash, K_2O / Water, H_2O	(16·35)
Silica, SiO_2	43·65
	100·00

Tungsten.—A small sample of wolfram (tungstate of iron, $FeWO_4$), partly coated with malachite, was sent to this laboratory some years ago by a prospector in the Roebourne district, under the impression that it was an ore of copper. Considerable quantities of scheelite (tungstate of calcium, $CaWO_4$) in masses often several pounds in weight, occur in the reefs at Lindsay's G.M., Coolgardie, and Fraser's G.M., Southern Cross. Although there is a steady demand for both these minerals at about £30 per ton, none would appear to have been exported.

Molybdenum.—Small scales of molybdenite (sulphide of molybdenum, MoS_2) have been detected in quartz from Clackline, Southern Cross, and Buldania. A single specimen of amphibolite, enclosing a small fragment of the same mineral, was picked up at Coolgardie.

Tantalum and Niobium.—Tantalite, tantalo-niobate of iron and manganese $(Fe.Mn)(Ta.Nb)_2O_6$, is of frequent occurrence in the tin-wash at the head of Floyd's and Bunbury gullies at Greenbushes, in water-worn pebbles and boulders up to five or six inches in diameter. The three largest boulders observed by the author weighed respectively 13, 4, and $3\frac{3}{4}$lbs. adp. This mineral occurs in greater or less quantity in all the alluvial deposits of the Greenbushes Tinfield; and, owing to its specific gravity being identical with that of tin-stone, is not removed from the latter by dressing, with the result that in many cases though the dressed ore is apparently clean, its assay value is low.

A mineral entirely confined to Greenbushes is stibiotantalite, a tantalo-niobate of antimony, $Sb(Ta.Nb)O_4$. This, like tantalite, occurs in the stream works, neither mineral having yet been discovered in their original matrix. The exact crystalline form of stibiotantalite has not been determined, the mineral occurring in water-worn pebbles with a very smooth bright surface. It is brittle, with a subconchoidal to granular or occasionally fibrous fracture. Its hardness is 5 to 5·5, and specific gravity 6·4 to 7·4. Its lustre is adamantine to resinous; colour, various shades of

yellow and brown, also grey. It is subtranslucent to opaque. Its composition is shown by the following analysis by Goyder:—

Antimony trioxide, Sb_2O_3	40·23
Bismuth trioxide, Bi_2O_3	·82
Nickel monoxide, NiO	·08
Tantalic oxide, Ta_2O_5	51·13
Niobic oxide, Nb_2O_5	7·56
	99·82

A hydrated variety of this mineral occurs also, resembling it in colour, but having a rough surface. Its formula would appear to be $2Sb(Ta.Nb)O_4 \cdot 7H_2O$. Before the blowpipe stibiotantalite is practically infusible and colours the flame greenish-grey. It is reduced to metallic antimony by fusion with potassium cyanide. In the closed tube the anhydrous mineral gives no sublimate; the hydrous, a sublimate of water. After mixing with sulphur it gives in the closed tube a sublimate which is black when hot and brownish red on cooling. It is soluble in hydrofluoric acid; this solution on adding a little potassium fluoride and evaporating somewhat, deposits on cooling a felt-like mass of colourless crystals of potassium fluotantalite. If some of the solution in hydrofluoric acid be poured into a platinum dish and a piece of pure zinc be dropped into it, a black stain immediately develops on the dish. Stibiotantalite is decomposed by fusion with potassium bisulphate.

ZIRCONIUM.—Small green zircons (silicate of zirconium, $ZrSiO_3$) are plentiful in the alluvial deposits of Spring Gully and other parts of the Greenbushes Tinfield. They have been found *in situ* in the tin-bearing greisen exposed in the Cornwall mine, and also in a non-stanniferous garnet-gneiss.

BERYLLIUM AND YTTRIUM.—Gadolinite (silicate of iron, beryllium and the yttrium metals) occurs in irregular masses up to several ounces in weight in granite at Coglegong Creek, Pilbarra Goldfield. Tinstone occurs in the adjacent creeks, and the gadolinite was at first taken by the miners for that mineral. It is black in colour, with a vitreous lustre, and a specific gravity of 4·25. On heating before the blowpipe it exhibits the characteristic flashing, and swells up and cracks, becoming greenish-grey in colour. Under the microscope the crushed mineral appears transparent and of a rich olive-green colour.

SALT.

Common salt (chloride of sodium, NaCl) forms a large proportion of the solid matter held in solution by underground waters, especially in those areas occupied by greenstones and greenstone schists. Such waters have been found to contain as much as 18 per cent. of it. The surface waters which collect on the dry lakes so plentifully distributed over the Southern interior are also salt, and on evaporation leave a more or less impure deposit of this mineral on the surface of the soil, sometimes reaching several inches in thickness.

On the small island of Rottnest, near Fremantle, are a series of depressions in the calcareous sandstone, which are filled to a shallow depth in winter with salt water, the salt in which is probably derived from sea spray. In the summer these lakes dry up completely, leaving a layer of salt two or three inches thick, which is collected by the aboriginals detained on the island, and sold by the Government for various industrial purposes. The crude salt thus collected is remarkably well crystallised in octahedra with axes an inch or more in length. A sample of it obtained from the heaps raked together on the dry lake bed during the summer of 1899-1900 was found to have the following composition:—

Soluble in Water	Sodium chloride, $NaCl$	96·798
	Magnesium chloride, $MgCl_2$	·349
	Calcium sulphate, $CaSO_4$	·636
Insoluble in Water	Calcium carbonate, $CaCO_3$	1·008
	Magnesium carbonate, $MgCO_3$	·046
	Ferric hydrate, $Fe_2(HO)_6$; Aluminium hydrate, $Al_2(HO)_6$	·021
	Silica, SiO_2	·017
	Water, H_2O	1·125
	Total	100·000

By dissolving this crude salt and recrystallising, all the insoluble matter can be removed from it, and a very pure article, containing only one per cent. of impurities other than water, can be obtained.

WATER.

Mineral Waters.—Most of the deep well waters of the State are to be classed as mineral waters, not so much because they contain mineral matter of an unusual kind as that they carry in solution abnormal quantities of the salts found in all natural waters.

…ine-Magnesian.				Saline Alkaline.	Saline Sulphated.	Magnesian Saline.	Alkaline Saline.
35	1276	1173	2688	1196	1571	1171	1573
…at …ver …I., …rdie. …rdie.	Hit or Miss South G.M., Mulgarrie. North-East Coolgardie.	Lake View and Boulder Junction G.M., Boulder. East Coolgardie.	Well, Public Battery, Lennonville Murchison.	Tarcoola North G.M., Southern Cross. Yilgarn.	Well, Walker's Hotel, Nullagine. Pilbarra.	Well, Mt. Robinson. East Coolgardie.	Public Well, Marble Bar. Pilbarra.
							H_2S = trace.
trace	trace	..	..	..	..	..	..
	·0031	..	..	..	..	..	..
197	·0700	·0700	..	·0084	..	trace	..
196	2·7174	3·2142	·4095	·3618	·1700	·0885	·0485
258	·3234	·5229	·0603	..	..	·0399	..
	..	..	..	·1025	·0227	..	·0009
	..	..	..	..	·0708	..	·0108
688	·4397	·3908	·0923	..	·0633	·0406	..
316	·0979	·1878	..	..	..	..	..
	..	..	..	·0749	..	..	·0106
	..	..	·0123	·0533	·0530	·0199	·0435
034	·0815	·0641	·0350	·0150	·0277	·0524	·0346
009	trace	..	·0017	·0005	·0003	..	·0002
	trace	..	..	·0030	..	..	..
033	·0014	·0009	·0026	..	·0025	trace	·0055
	..	..	..	·0084	..	..	..
083	·0004	·0047	·0008	·0002	·0009	trace	·0002
314	3·7348	4·4554	·6145	·6280	·4112	·2413	·1548
·	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.
240	1·0286	1·0338	1·0050	1·0043	1·0033	1·0020	1·0014

TABLE XIII.—*Complete Analyses of Mineral Waters.*

Classification.	Saline.								Saline-Magnesian.						Saline Alkaline.	Saline Sulphated.	Magnesian Saline.	Alkaline Saline.
Number of Sample	1452	1336	1339	1278	1172	863	864	2253	1174	1181	1335	1276	1173	2688	1196	1571	1171	1573
Source of Water.	Rose Hill G. M., Coolgardie. Coolgardie.	South Gippsland G.M., Vosperton. North-East Coolgardie.	Well, Water Reserve, Lindsays. North-East Coolgardie.	Golden Lead G.M., Mulgarrie. North-East Coolgardie.	Well, West side of Hannan's Lake. East Coolgardie.	Trenches at Desirable G.M., Lake Cowan. Dundas.	Government trenches Norseman, Lake Cowan. Dundas.	Well, Public Battery, Mulline. North Coolgardie.	Princess Royal G.M., Cue. Murchison.	Menzies Consolidated G.M., Menzies. North Coolgardie.	Great Hanover G.M., Coolgardie. Coolgardie.	Hit or Miss South G.M., Mulgarrie. North-East Coolgardie.	Lake View and Boulder Junction G.M., Boulder. East Coolgardie.	Well, Public Battery, Lennonville Murchison.	Tarcoola North G.M., Southern Cross. Yilgarn	Well, Walker's Hotel, Nullagine. Pilbarra.	Well, Mt. Robinson. East Coolgardie.	Public Well, Marble Bar. Pilbarra.
																		H_2S = trace.
Sodium iodide, NaI	..	..	slight trace	..	..	trace	..	..	..	..	slight trace	trace	..	..	..	..	..	..
Sodium bromide, NaBr	slight trace	trace	..	strong trace	..	..	..	..	slight trace	slight trace	..	·0031	..	..	..	..	..	..
Potassium chloride, KCl	·0047	·0547	..	·0349	strong trace	·0513	·0738	..	·0250	·0076	·0197	·0700	·0700	..	·0084	..	trace	..
Sodium chloride, NaCl	1·7659	3·0018	·4398	3·2303	12·8371	10·4901	18·8806	·8985	·2748	2·6449	2·0196	2·7174	3·2142	·4095	3618	·1700	·0885	·0485
Magnesium chloride, $MgCl_2$	·0662	·3027	..	·2066	1·9260	1·5362	3·1905	·0478	·0313	·2696	·1258	·3234	·5229	·0603	..	..	0399	..
Potassium sulphate, K_2SO_4	..	..	trace	..	..	..	..	..	..	..	..	..	..	..	·1025	·0227	..	0009
Sodium sulphate, Na_2SO_4	..	..	·0887	..	..	..	..	..	..	..	..	..	..	..	..	·0708	..	0108
Magnesium sulphate, $MgSO_4$	·4192	·2512	·0216	·3116	·4921	·3417	1·1324	·1728	·0812	·4787	·4688	·4397	·3908	·0923	..	·0633	·0406	..
Calcium sulphate, $CaSO_4$	·0184	·1598	..	·1105	·3984	·5393	·2238	·0095	·0044	·1607	·0316	·0979	·1878	..	..	..	..	..
Sodium bicarbonate, $NaHCO_3$	..	..	..	..	..	..	..	..	..	..	..	..	..	..	·0749	..	..	·0106
Magnesium bicarbonate, $MgH_2(CO_3)_2$ ..	..	..	·0555	..	..	..	..	..	..	..	..	..	..	·0123	·0533	·0530	·0199	·0435
Calcium bicarbonate, $CaH_2(CO_3)_2$	·1015	·0393	·0230	·0111	·0084	·0150	·0124	·0376	·0494	·0217	·1034	·0815	·0641	·0350	·0150	·0277	·0524	·0346
Ferrous bicarbonate, $FeH_2(CO_3)_2$	·0009	·0008	..	·0017	trace	slight trace	..	..	·0005	·0004	·0009	trace	..	·0017	·0005	·0003	..	0002
Sodium nitrate, $NaNO_3$	..	slight trace	..	..	..	..	..	..	..	..	..	trace	..	..	·0030	..	..	..
Silica, SiO_2	·0040	·0037	·0003	·0032	·0047	trace	trace	·0077	·0047	·0023	·0033	·0014	·0009	·0026	..	·0025	trace	·0055
Sodium silicate, Na_2SiO_3	..	..	..	..	..	..	..	..	..	..	..	..	..	..	·0084	..	..	..
Alumina, Al_2O_3	·0039	·0079	trace	·0031	·0038	·0058	·0044	·0020	·0009	·0029	·0083	·0004	·0047	·0008	·0002	·0009	trace	·0002
Total Mineral Matter in Solution	2·3847	3·8219	·6289	3·9130	15·6705	12·9794	23·5179	1·1759	·4722	3·5888	2·7814	3·7348	4·4554	·6145	·6280	·4112	·2413	·1548
Reaction with Methyl-orange	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk.	Alk
Specific Gravity at 4° C.	1·0183	1·0284	1·0051	1·0297	1·1201	1·0993	1·1862	..	1·0036	1·0282	1·0240	1·0286	1·0338	1·0050	1·0043	1·0033	1·0020	1·0014

Results expressed in parts per cent.

Common salt is constantly present in them, generally in amounts largely exceeding the totals of all the other mineral matters in solution. Part of this is doubtless derived from rain, but the most important source is the more basic rocks, diorites, and amphibolites, many of which have been subjected to intense metasomatic action in which chlorine (either free or as hydrochloric acid) has played an important part, decomposing the original soda felspars of the rock and forming sodium chloride.

Of the remaining constituents chloride and sulphate of magnesium are the most important. These salts also have been derived from the decomposition of the basic rocks, the former being due to the action of chlorine, the latter to that of sulphuric acid and sulphate of iron, set free by the oxidation of pyrites and other sulphides.

Calcium sulphate is usually present to a notable extent, originating in the same way as the corresponding salt of magnesium. Calcium carbonate is invariably present in small amounts, being derived probably from the decomposition of lime felspars and other silicates by water charged with carbonic acid. Its presence is always indicated by the alkaline reaction of the water with methyl-orange, etc.

Minute amounts of alumina and silica are also invariably present. No free sulphuric or other acid, other than carbonic and silicic, have so far been detected. This is only natural, seeing that the greenstones and other rocks of the areas from which water samples have been obtained contain so much calcium and magnesium carbonate, which would immediately neutralise any strong mineral acid.

Any attempted classification of mineral waters must necessarily be more or less inexact, owing to the large number of constituents usually present in all, and the wide variations each one of these may have independent of the others. The West Australian waters have, somewhat arbitrarily perhaps, been classified as follows:—

(1.) *Saline.*—Total solid matter contains over 60 per cent. sodium chloride, under 20 per cent. of any other class of salts.

(2). *Saline-magnesian.*—Over 40 per cent. sodium chloride, over 20 per cent. magnesium salts.

(3.) *Saline-alkaline.*—Over 40 per cent. sodium chloride, over 20 per cent. bicarbonates.

(4.) *Saline-sulphated.*—Over 40 per cent. sodium chloride, over 20 per cent. sulphates.

(5.) *Magnesian-saline.*—Over 40 per cent. magnesium salts, over 20 per cent. sodium chloride.

(6.) *Alkaline-saline.*—Over 40 per cent. bicarbonates, over 20 per cent. sodium chloride.

In Table XIII. are shown all the analyses of mineral waters made in the laboratory.

Almost all of the waters, whose analyses appear in the foregoing table, have been largely used for domestic or industrial purposes. The average miner apparently drinks with relish any water containing not more than 0·2 per cent. (140 grains per gallon) of solid matter in solution, whilst the presence of as much as three times that amount, much of it being salts of magnesium, does not prevent the consumption of some waters. Water containing as much as 3 or 4 per cent. of solid matter is used frequently for steam raising on the goldfields, with disastrous results to boilers, partly from the rapid collection of scale and sediment at the bottom, and partly from the energetic corrosion of the plates by the magnesium chloride in the water. Water carrying as much as $23\frac{1}{2}$ per cent. of solid matter in solution (sample 864) is used for battery purposes, with what would appear in some cases to be very unfavourable results. It is difficult, however, to obtain definite and unbiassed data on this point, and it is, therefore, impossible at present to decide whether the very serious difficulties which have undoubtedly been met with in battery treatment in some districts are to be entirely ascribed to the water used. The symptoms in most cases seem to be identical, viz., (1.) The formation and collection on the plates of a large amount of iron amalgam, resulting in a low-grade alloy of iron and gold being obtained from the retorts; (2.) an unduly large loss of gold in the tailings. It seems to me that the latter is only the natural effect of the former, but it is generally ascribed to the higher specific gravity and viscosity of these saline waters preventing the gold from settling on to the plates. With regard to the former phenomenon, it should be noted that inferior brands of cast iron are largely employed for battery dies and shoes, which consequently wear very rapidly, and that sodium amalgam, which will amalgamate iron, is looked upon as the universal panacea for all battery troubles, and is consequently used regularly in excessive quantities. There may, however, in some cases, be a connection between the use of these waters and the formation of iron amalgam, for it has been found that many of them are capable of dissolving copper, which would be rapidly precipitated on the scales of iron and cause them to adhere to the plates.

For domestic purposes saline waters are usually condensed. The condensing plants are on a large scale, and form a most conspicuous and unique feature in the landscape on the goldfields. (Plate V.) The product of this distillation is very pure, and, although unpleasant to drink immediately after distillation, becomes very palatable after exposure to the air for a few hours. Condensed water is also used for the boilers on many of the larger mines, the original source of the water being the mine workings, which usually afford a copious supply.

Plate V.—Water-condensing Plant, Kalgoorlie.

Most of the mineral waters of the State contain sufficient magnesia to make them purgative, but apart from this no springs of therapeutic importance have been discovered.

The following determinations have been made of chlorine and fixed carbonic acid in five additional samples from Cue :—

No.	Source of Water.	Chlorine.	Carbonic Acid in Mono-carbonates.
		per cent.	per cent.
1175	Shaft, Cue One G.M.	·2253	·0060
1176	Shaft, Polar Star G.M.	·0541	·0098
1177	Shaft, Lady Forrest G.M.	·1867	·0091
1178	Public Well, Caledonian Smelting Co.	·0433	·0070
1179	Government Well	·0346	·0084

Perth Artesian Water Supply.—The water with which the City of Perth is supplied is drawn from two sources, viz., a reservoir in the Darling Ranges, at the head of the Canning River, and the artesian supply existing beneath the City itself. Artesian water is drawn from three bores, one in Wellington Street, in the City of Perth, one each in the suburbs of Leederville and Subiaco. An additional bore has recently been put down at the east end of Adelaide Terrace, in the City. The largest amount of bore water is taken from the Wellington Street bore. An analysis of a sample taken from this bore in January, 1901, gave the following results :—

	per cent.
Sulphuretted hydrogen, H_2S	.00004
Potassium chloride, KCl	·00208
Sodium chloride, $NaCl$	·03750
Magnesium chloride, $MgCl_2$	·00386
Do. sulphate, $MgSO_4$	·00255
Do. bicarbonate, $MgH_2(CO_3)_2$ ...	·00242
Calcium bicarbonate, $CaH_2(CO_3)_2$	·01205
Silica, SiO_2	·00196
Alumina, Al_2O_3 / Ferric oxide, Fe_2O_3	·00083
Per cent.	·06329
Grains per gall.	44·30

COAL AND PEAT.

Coal of three different ages is known in the State, viz., in the Carboniferous Beds of the Irwin River, the Mesozoic Beds of the South-West, and the Post-Tertiary Beds of Coolgardie and the South Coast. All the coal hitherto discovered has proved to contain a considerable proportion of water, belonging either to the class of splint (hydrous bituminous) coals or to that of lignites.

Carboniferous Coals.—No analyses of these coals have been made in this Department, but the following, made elsewhere, represent the composition of the outcrop of a seam in the Irwin River beds.

	I.	II.	III.
Moisture	17·04	12·40	15·63
Volatile hydro-carbons	28·61	32·20	23·06
Fixed carbon	41·29	43·50	39·32
Ash	13·06	11·90	21·99
	100·00	100·00	100·00
Sulphur	...	·83	...
Analyst	Harland	Wingham	Woodward

The average percentage of incombustible material in this coal is high, viz., 30·67 per cent.

Mesozoic Coals.—These include the mineral from the Collie, which is the only district where there are any working coal mines, and which is credited up to the end of 1900 with a total production of 176,254 tons. A considerable number of workable seams have been proved, by mining and boring, to exist in this basin, the deepest so far met with being pierced at 800ft. on the Collie Boulder Company's property. All these seams are practically identical in nature, being hydrous, non-caking, bituminous coals, varying noticeably only in the proportion of ash present.

The coal from the better portions of the seams is bright and evenly bedded, but fragile, partly owing to the numerous partings of mother-of-coal in it, partly owing to spontaneous decrepitation accompanying a loss of moisture on exposure to the air. The composition of such a coal is shown in Table XIV., No. 715. The poorer qualities of coal contain considerably larger percentages of ash and correspondingly smaller proportions of the other constituents, becoming physically harder, denser, and more massive, with a conchoidal fracture, resembling, in fact, in outward appearances, the "kerosene shale" of the New South Wales coalfields. No. 714 in the table is a coal of this nature.

TABLE XIV.—*Proximate Analyses of Collie Coal.*

No. of Analysis.	Description of Sample.	Specific Gravity.	Calorific Value.		Percentage Composition.				
			Pounds of Water evaporated.	British Thermal Units.	Moisture.	Volatile Hydro-carbons.	Fixed Carbon.	Ash.	Sulphur.
215	West Collie Proprietary; air-dried for six months	1·211	12·10	11,690	10·93	32·86	52·87	3·34	·59
367	Collie Trust	1·384	10·60	10,240	10·67	39 17	44·74	5·42	1·44
396	Do.	1·325	11·30	10,920	11·58	35·92	49·92	2·58	·48
535	West Collie Proprietary ?	1·356	10·40	10,050	13·95	27·89	52·25	5·91	·44
665	Westralian Wallsend (late Government Mine)	1·419	11·15	10,770	12·03	25·65	54·78	7·54	·10
666	West Collie Proprietary; Top Coal	1·327	11·55	11,160	12·07	31·75	48·10	8·08	2·00
667	Do. do. Bottom Coal	1·417	10·45	10,090	10·60	26·00	46·85	16·55	·40
669	Collie Proprietary	1·409	10·12	9,770	13·98	25·82	53·51	6·69	·05
710	West Collie Proprietary	1·319	11·16	10,780	13·87	32·62	45·63	7·88	...
711	Do. do.	1·356	10·61	10,250	11·22	29·58	44·89	14·31	...
712	Do. do.	1·436	10·50	10,140	10·73	28·35	45·05	15·87	...
713	Do. do.	1·448	9·73	9,400	10·98	25·58	45·33	18·11	...
714	Do. do.	1·468	9·52	9,200	10·33	25·48	45·63	18·56	...
715	Do. do. depth, 120ft.	1·267	11·82	11,420	14·57	36·61	44·80	4·02	...
1159	Westralian Wallsend Colliery	1·368	9·95	9,610	15·05	21·95	53·30	6·70	·23
1161	Do. do.	1·405	10·00	9,660	13·79	27·89	51·18	7·14	·17
1170	Do. do.	1·408	10·18	9,830	14·17	26·63	52·43	6·77	·19
1221	?	1·364	10·71	10,350	11·48	31·95	49·14	7·43	...
2497	Westralian Wallsend Colliery No. 1 Bore, 3ft. 6in. Seam at 250ft. ...	1·412	10·59	10,230	12·89	31·58	43·37	12·16	·39
2498	Do. do. do. 8ft. do. 471ft. ...	1·415	10·29	9,940	12·76	27·14	49·40	10·70	·33
2499	Do. do. do. 7ft. 2in. do. 500ft. ...	1·428	10·59	10,230	12·81	30·07	47·59	9·53	·30
2500	Do. do. do. 17ft. do. 543ft. ...	1·418	10·98	10,600	13·10	28·83	50·35	7·72	·31
2501	Do. do. do. 4ft. 6in. do. 634ft. ...	1·369	11·97	11,560	12·93	29·30	51·44	6·33	·59
		1·379	10·71	10,340	12·46	29·63	48·81	9·10	·50

Owing to the presence of numerous fine films and crystals of pyrites, and to decrepitation causing the exposure of a large surface of finely powdered coal to the oxidising action of the air, the Collie coal is found to heat rapidly and fire spontaneously if stacked in large heaps. In furnaces it is found to be somewhat difficult to ignite, and throws off a considerable amount of sparks, but once alight burns well with a good draught, giving a short flame and generating a high temperature. It is practically smokeless, and is, therefore, admirably suited for use in city factories.

With regard to its efficiency, the figures in Table XV. representing the results of recent tests of Newcastle (N.S.W.) and Collie coals at the Fremantle Smelting Works, speak for themselves.

TABLE XV.—*Results of Boiler Tests of Newcastle and Collie Coals.*

	Newcastle.	Collie I.	Collie II.	Collie III.
Analysis—				
Moisture	2·56	19·12	14·10	13·85
Volatile hydro-carbons ...	29·34	16·68	22·40	23·05
Fixed carbon	60·45	55·15	53·70	50·90
Ash	7·65	9·05	9·80	12·20
Consumption per 24 hours, tons	8·1	10·5	11·4	11·1
Cost, per ton ... ... £	1·537	1·004	1·004	1·004
Total per 24 hours ... £	12·458	10·542	11·446	11·144

Although the coal in the outcrops was found at the outset to be non-caking, hopes were entertained in some quarters that as a greater depth was attained in the mines the coal might so far alter in nature as to become caking. All doubts on this point, however, have been settled by the results of recent boring operations at the Westralian Wallsend Mine. A bore put down there to a depth of 650 feet, at the latter end of 1900, cut, besides sundry smaller seams, five workable seams, totalling 40 feet in thickness. The coal in all these seams was found to be identical in character with that near the surface. Analyses of it are given in Table XIV.

The only ultimate analyses of this coal yet published are those made in England in 1895 on a sample from a depth of 100 feet in the Government (now Westralian Wallsend) Mine. They are as follows:—

	Before drying.	After drying.	
Carbon...	63·21	71·66	72·26
Hydrogen	3·53	3·99	3·77
Oxygen and nitrogen	14·43	16·33	15·18
Sulphur	·23	·26	·41
Ash	6·85	7·76	8·38
Water	11·75	...	...
	100·00	100·00	100·00
Analyst	Sutherland	Sutherland	Johnson & Sons

As the high percentage of ash in some of this coal is its most marked drawback, an experiment was made to ascertain whether washing would improve it appreciably in this respect. The sample chosen was that numbered 711 in Table XIV. Its analysis before and after washing was as follows:—

	Before washing.	After washing.
Moisture	11·22	11·23
Volatile hydro-carbons ...	29·58	34·70
Fixed carbon	44·89	43·05
Ash	14·31	11·02
	100·00	100·00

The ash was therefore reduced 23 per cent. by the washing.

As elsewhere, bands of hard shaley material are found in the better coal. These are intermediate in character between a true coal and a carbonaceous shale, and carry so much ash as to render them valueless as fuel. The following are proximate analyses of three typical specimens of this material:—

	No. 668. West Collie Proprietary.	No. 716. West Collie Proprietary.	No. 1281. Collie Coalfield Proprietary.
Moisture	9·10	8·94	12·21
Volatile hydro-carbons...	27·18	29·61	21·53
Fixed carbon	33·85	27·57	41·58
Ash	29·87	33·88	24·68
	100·00	100·00	100·00
Specific gravity	1·565	1·525	...
Calorific value	6914 B.T.U.	9570 B.T.U.	...

A narrow seam of coal very similar in appearance and composition to the Collie coal was struck in a bore at Dardanup, on the Coastal Plain, near Bunbury. A narrow seam also was met with at a depth of 265 feet in the Dongara bore. The following are proximate analyses of these coals, the exact age of which is not known with certainty:—

	Dardanup.	Dongara.
Moisture	14·36	13·13
Volatile hydro-carbons ...	35·89	29·47
Fixed carbon	46·14	49·40
Ash	3·61	8·00
	100·00	100·00
Analysts	J. H. Brooking.	E. S. Simpson.

Several seams of coal were opened up some years ago at Fly Brook, on the South Coast. The coal was highly lustrous, and of the same character as the Collie coal. The mean of three analyses made in Melbourne and Adelaide was :—

Moisture	16·40
Volatile hydro-carbons	38·23
Fixed carbon	43·52
Ash	1·85
	100·00

Tertiary and Post-Tertiary Coals.—Lignites and brown coals, mostly of poor quality, are known to occur in several of the valleys along the South Coast. The only sample (G.S.M. 2996) hitherto analysed in this department was from the Fitzgerald River. Its composition was :—

Moisture	22·08
Volatile hydro-carbons	37·32
Fixed carbon	27·76
Ash	12·84
	100·00

This coal is dark brown in colour, and presents in places a ligneous structure. It cracks considerably and becomes very fragile on exposure to the air.

At Coolgardie a valley to the south-east of the town, bounded on either side by hills of amphibolite, has been found to be underlain by 400 feet of horizontally bedded rocks of Pleistocene age. At a depth of 65ft. in these deposits a seam of brown coal was struck in Olsen's claim, and penetrated for several feet. It was dark brown in colour, free from ligneous structure, and conchoidal in fracture, having a consistency of wax. It is not fissile horizontally, only occasionally showing indistinct traces of bedding planes. Fossil leaves of Dryandra, etc., in an excellent state of preservation are comparatively numerous. Proximate analyses of this mineral gave the following results :—

	No. 529.	No. 624.	No. 700.
Moisture	30·56	41·73	24·24
Volatile hydro-carbons and combined water	23·62	19·35	29·81
Fixed carbon	9·45	7·84	5·51
Ash	36·37	31·08	40·44
	100·00	100·00	100·00
Specific gravity	...	...	1·493

On exposure to the air this coal rapidly loses some of its moisture, becomes harder and darker in colour, and develops cracks in various directions through it.

A portion of No. 624 was coarsely crushed and dried in the air for three weeks, after which it was found to have the following composition:—

	Per cent.
Moisture	31·79
Volatile hydro-carbons and combined water...	23·04
Fixed carbon	8·67
Ash	36·50
	100·00

Above the beds of coal at Coolgardie is a shale of a light coffee colour, in which leaf impressions are numerous. On distillation this yields, besides water, a little tar, oil, and gas, but not in sufficient quantity to render it of economic importance. Its proximate composition is:—

	No. 527.
Moisture	29·71
Volatile hydro-carbons and combined water...	12·93
Fixed Carbon	2·04
Ash	55·32
	100·00

PEAT.—Peat is known to occur in most of the swamps along the coast between Geraldton and Albany, but no analyses have ever been made of it.

GRAPHITE.

No massive samples of clean graphite have ever reached the laboratory of the Department, but specimens of graphite schists have been forwarded from several different portions of the State, notably, Cue, Coolgardie, Kalgoorlie, Oldfield River, Mounts Brook, and the Donnelly River. Some attempts have been made to work the deposits at the last-named locality at various times, but the mineral produced has, so far, failed to find a market. The following are three analyses of it made by C. C. Williams.—

	I.	II.	III.
Moisture	1·30	4·16	2·01
Volatile matter* ...	5·67	6·41	5·26
Fixed carbon ...	24·86	19·21	21·61
Ash	68·17	70·22	71·12
	100·00	100·00	100·00

* Includes combined water.

The ash consists of silica, alumina, and iron oxide, with traces of lime, magnesia, and alkalis. The material is therefore to be looked

upon as a graphitic slate, probably the result of metamorphism of a carbonaceous shale.

A sample of similar material from Mounts Brook, S.W., was found to have the following composition :—

Moisture	1·32
Volatile matter*	10·26
Fixed carbon	23·50
Ash	64·92
	100·00

SILICATES.

Topaz.—A few miles West of the Londonderry Gold Mine, Coolgardie Goldfield, and close to the junction of the granite and amphibolite, are several dykes of very coarse-grained granite traversing the latter. These dykes are composed mainly of quartz, orthoclase, lepidolite, and a very hard sky-blue mineral at first taken to be cyanite but since shown to be topaz. All the chief constituents of these dykes are found in large masses, ranging up to 100lbs. or more in weight. One of the dykes has been opened up by a quarry to some depth in order to extract the lithia mica. The topaz which accompanies it occurs in rough crystalline masses of all sizes. A specimen (554) in the Departmental Museum weighs 2lbs. 11ozs. adp., and is mostly of irregular outline showing only traces of crystal faces (which in places show a strong vertical striation) but possessing a perfect basal cleavage. It is semi-transparent in mass, and light sky-blue in colour in the centre, fading off to milky whiteness towards the edges. An analysis of the clear blue portion gave the following results :—

Specific Gravity ... ... 3·60

Silica, SiO_2	32·11
Lime, CaO	Trace
Ferrous oxide, FeO	·26
Aluminium, Al†	30·48
Oxygen, O	19·10
Fluorine, F	17·86
Water, H_2O combined	·78
,, ,, hygroscopic	*Nil*
	100·59

* Includes combined water. † Equal to Al_2O_3, 57·08. per cent.

Lepidolite.—The lithia mica associated with the topaz described above is of an amethystine colour, and has been obtained in sheets as large as 15 inches long by 12 inches. It has the following composition:—

Specific Gravity	2·75
Silica, SiO_2	51·00
Lime, CaO	Trace
Manganous oxide, MnO	1·20
Ferrous oxide, FeO	Trace
Aluminium, Al*	12·89
Oxygen, O	7·96
Fluorine, F	7·79
Lithia, Li_2O	5·97
Potash, K_2O	10·31
Soda, Na_2O	2·43
Water, H_2O combined	·22
	99·77

Analyst ... ... C. G. Gibson.

Spodumene.—About half-a-mile South of Ravensthorpe there is a dyke of tourmaline granite, carrying large prismatic crystals of apple-green spodumene. A sample of this mineral (1864) was analysed with the following results:—

Specific Gravity	3·20
Silica, SiO_2	61·94
Lime, CaO	·28
Manganous oxide, MnO	Trace
Ferrous oxide, FeO	1·82
Alumina, Al_2O_3	26·48
Lithia, Li_2O	7·02
Potash, K_2O	·47
Soda, Na_2O	1·93
Water, H_2O, combined	·29
	100·23

Analyst ... ... C. G. Gibson.

Clays.

Brick Clays.—No analyses have been made of the brick-clays which are being worked in many parts of the State.

* Equal to Al_2O_3, 24·13 per cent.

Fire Clay.—Fire clay has been worked at the West Collie (Moira) Colliery, Collie River. A sample of this clay had the following composition :—

Water, H_2O, hygroscopic	·54
,, combined	11·23
Silica, SiO_2	51·95
Alumina, Al_2O_3	29·58
Ferric oxide, Fe_2O_3	3·40
Lime, CaO	Trace
Magnesia, MgO	1·01
Potash, K_2O	·63
Soda, Na_2O	1·09
	99·43

Porcelain Clay, etc.—Extensive beds of porcelain clay and terra cotta have been proved by boring to overlie the extension of the deep lead at Kanowna.

Mineral Fat.—A clay having, when freshly extracted, the consistency of tallow is found in vughs in the reef at the Norseman Gold Mines, Ltd., Norseman. It is faintly greenish in tinge when fresh and moist, but on exposure to the air changes in colour to brown and loses water rapidly, becoming first waxy and then dry and granular in consistency. Its composition was found to be :—

	Wet Mineral.	Dry Mineral.
Water H_2O lost over sulphuric acid ...	49·17	...
,, ,, lost on subsequent ignition ...	9·80	19·08
Silica, SiO_2	20·30	39·53
Alumina, Al_2O_3	18·03	35·11
Ferrous oxide, FeO	·44	·86
Manganous oxide, MnO	Trace	Trace
Lime, CaO	·15	·29
Magnesia, MgO	·22	·43
Potash, Ka_2O	·05	·10
Soda, Na_2O	2·36	4·60
	100·52	100·00

This would correspond to the formula $Al_2O_3{\cdot}2SiO_2{\cdot}3H_2O + 15H_2O$.

The formulæ given by Dana to the only four minerals approaching this in composition, are :—

Halloysite ...	$Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O + nH_2O$; or
	$Al_2O_3{\cdot}2SiO_2{\cdot}3H_2O + nH_2O$
Newtonite ...	$Al_2O_3{\cdot}2SiO_2{\cdot}4H_2O + H_2O$
Montmorillonite	$Al_2O_3{\cdot}4SiO_2{\cdot}H_2O + nH_2O$
Kaolinite ...	$Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O$

The Norseman mineral agrees exactly in formula with halloysite, although in outward appearances it resembles more closely some forms of montmorillonite.

CARBONATES.

Travertine.—As the result of the surface weathering of the basic rocks of the goldfields, considerable deposits of impure carbonate of lime are formed. A yellow incrustation on the greenstones at the Boulder Perseverance Mine, Boulder, was found to have the following composition:—

	Nitrogenous Organic Matter	Strong Trace
	Water, H_2O at 100° C.	1·80
	„ „ at Red Heat	3·99
Soluble in Hydrochloric Acid.	Lime, CaO	29·98
	Magnesia, MgO	2·87
	Ferrous oxide, FeO	1·11
	Ferric oxide, Fe_2O_3	4·87
	Alumina, Al_2O_3	·14
	Carbonic anhydride, CO_2	25·66
	Sulphuric anhydride, SO_3	·28
	Phosphoric anhydride, P_2O_5	Trace
Insoluble.	Lime, CaO	·20
	Magnesia, MgO	·24
	Ferrous oxide, FeO	Trace
	Alumina Al_2O_3	1·69
	Potash, K_2O	Trace
	Soda, Na_2O	1·35
	Silica, SiO_2	25·59
		99·77
	Specific Gravity	2·29

Dolomite.—Fine cleavage rhombohedra of dolomite have been received from Goongarrie. One such rhombohedron in the Departmental Museum measures 6in. x 2in. x 2in., is semi-transparent to opaque, and varies in colour from creamy-white to light brown. Its most striking pecularity is a perfect system of surface striations, accompanied by internal milky banding in three vertical planes parallel to the prism faces 1010, etc. Its composition is:—

Lime, CaO	28·86
Magnesia, MgO	18·26
Ferrous oxide, FeO	5·40
Carbonic anhydride, CO_2	47·48
Silica, SiO_2	Trace
	100·00

PART II.

Petrology.

ROCKS OF THE DARLING RANGES.

The rocks which form the Darling ranges, with their Northerly and Southerly extensions, are mainly massive and foliated granites traversed by numerous dykes of more basic rocks, usually of a dioritic type. The following are analyses of three specimens of typical rocks from this area.

TABLE XVI.—*Analyses of Rocks from the Darling Ranges.*

No.	798	1,419	200
Specific Gravity	2·62	3·08	3·07
Silica, SiO_2	72·00	50·96	53·06
Titanic oxide, TiO_2	·38	1·84	...
Alumina, Al_2O_3	12·46	11·89	13·67
Ferric oxide, Fe_2O_3 ...	·62	2·54	4·83
Ferrous oxide, FeO ...	3·13	13·64	9·96
Manganous oxide, MnO ...	Trace	·34	·56
Lime, CaO	1·41	9·94	8·62
Magnesia, MgO	·27	6·26	5·31
Potash, K_2O	5·89	·29	1·29
Soda, Na_2O	3·47	2·68	3·22
Water, H_2O, Hygroscopic ...	·15	·16	·38
Water, H_2O, Combined ...	·26	·05	
Carbonic anhydride, CO_2 ...	·03	*Nil.*	
	100·07	100·59	100·90
Analyst ...	Williams.	Simpson.	Simpson.

No. 798. Granite, Bannister, Williams District.

No. 1419. Diorite, Smith's Mill, Swan District. Largely composed of dark green hornblende with granular plagioclase and a considerable amount of ilmenite. Weathers into a rich chocolate soil.

No. 200. Diorite (Diabase), Northampton, Victoria District. A coarse-grained rock consisting almost entirely of multiply-twinned felspar and augite. Some magnetite also present.

Once the escarpment of the ranges is passed the crystalline rocks are found to be covered by a mantle of a hard nodular ferruginous rock which is best described by the term "Laterite." Large areas of this material have been stripped for use as ballast on the streets of Perth and Fremantle, and good sections of the rock can be seen in the faces of these workings. Passing from the surface downwards the following rocks are found to be exposed :—

(1.) One or two inches of loose concretionary pebbles mixed with a little sand and earth.

(2.) From one to ten feet of hard laterite, varying in composition from an almost pure bauxite to an almost pure limonite or turgite. It is usually mottled, yellow and brown in colour, and concretionary in structure. Numerous sharp grains of quartz, and sometimes orthoclase are embedded in it. Immediately below this we find either

(3.) Solid granite, or

(3*a*.) Ferruginous clay often passing insensibly into the overlying laterite. Then

(3*b*.) White pipeclay. Below which again comes

(3*c*.) Solid granite or diorite from which the whole of the overlying rocks would seem to be derived by decomposition *in situ.*

Analyses of purer ferruginous types of this laterite will be found in the chapter on iron, and of the more aluminous varieties in that on aluminium. The following is an analysis of an ordinary mottled sample of this rock :—

Silica, SiO_2	13·74
Titanic oxide, TiO_2	4·33
Alumina, Al_2O_3	31·14
Ferric oxide, Fe_2O_3	35·54
Lime, CaO	·16
Magnesia, MgO...	Trace
Water, H_2O, hygroscopic ...	·69
,, ,, combined	14·71
	100·31

A notable feature of the analyses of these rocks is the large percentage of titanic oxide present in them.

ROCKS OF THE EUCLA LIMESTONE AREA.

At the head of the Great Australian Bight there is a large area of limestone rocks of presumably Tertiary Age stretching inland for about 150 miles. During the recent transcontinental railway exploratory survey several samples of this limestone were collected by Mr. J. Muir. These were presented to the Departmental Museum, and the following rough analyses of them were made to ascertain the suitability of the stone for burning into lime.

TABLE XVII.—*Analyses of Limestone from the Eucla Division.*

No.	3043	3044	3045	3047	3053
Specific Gravity...	2·69	...	...	2·57	2·58
Lime, CaO ...	31·36	53·73	54·52	55·23	49·34
Magnesia, MgO ...	16·40	·68	1·20	·67	1·40
Ferrous oxide, FeO	1·48	·56	...	...	1·47
Ferric oxide, Fe_2O_3	1·02	Trace	·65	·38	...
Alumina, Al_2O_3 ...	2·43	·24			3·41
Silica, SiO_2 ...	2·38	·70	·45	·36	5·49
Carbonic anhydride, CO_2, etc.	44·93	44·09	43·18	43·36	38·89
	100·00	100·00	100·00	100·00	100·00
Analyst ...	Simpson.	Simpson.	Williams.	Williams.	Williams.

No. 3043.—From Lat. 31° 17′, Long. 124° 30′.
No. 3044.—From Lat. 31° 22′, Long. 125° 45′.
No. 3045.—From Lat. 31° 30′, Long. 126° 0′.
No. 3047.—From near Yayoudle Rock-hole.
No. 3053.—From Lat. 31° 0′, Long. 126° 0′.

ROCKS OF KALGOORLIE.

In the description of the rocks of the Kalgoorlie district given by previous writers on the subject, the following five classes are referred to:—

(1.) A series of green rocks more or less highly metamorphosed, to which various origins have been ascribed.

(2.) Lode stuff intimately associated with the green rocks above mentioned.

(3.) Slate of sedimentary origin.

(4.) Jasper, considered to represent zones of secondary silicification; and

(5.) Surface ironstones.

During the last three years a very complete series of rocks has been collected by members of the staff from an area of about 12 miles by six miles, including the townships of Kalgoorlie and Boulder, and all the working mines in the vicinity. Of these a considerable number have been analysed, and many more examined under the microscope. The results of this investigation lead to the classification of the rocks under four heads:—

(1.) Amphibolites and their derivatives, including most of the lode stuff.

(2.) Newer Eruptives, both acid, intermediate, and ultra-basic.

(3.) Older Sediments ; and

(4.) Newer Sediments.

These will be considered in detail in the above order.

(1.) Amphibolites and their Derivatives.

These rocks, which form not only the country rocks of the productive ore-bodies of Kalgoorlie, but also, in a much altered form, the greater number of the "lode-formations" themselves, possess the highest interest. Owing to the varying and sometimes extreme alteration that they have undergone, the rocks present an almost endless variety of form and (within certain limits) composition. They appear to resemble very closely the greenstone schists of the south shore of Lake Superior, which are associated with important deposits of iron ore. The Kalgoorlie amphibolite rocks are of four main types, viz., massive and foliated amphibolites, massive and foliated greenstone (chlorite-rock), chlorite schist, and massive and foliated siderite-rock. Table XVIII. gives the results of analyses of these rocks, whilst some further partial results are embodied in Table XIX.

The rock to which the term Amphibolite has been applied varies in character, but constantly carries a considerable amount of hornblende together with more or less plagioclase. Some specimens, to the unaided eye, appear to consist wholly of dark or light green hornblende in irregular crystals up to several inches in length. Others again appear to consist of about equal proportions of hornblende and felspar. Analyses 2117 (Table XVIII.), 1954 (Table XIX.), are typical of the former class, analysis 3231 (Table XVIII.) of the latter. The percentage of silica is identical (44·2) in 2117 and 1954, which were collected from two points $3\frac{1}{2}$ miles apart, and is too low to permit of the rock being classed with the intermediate eruptives. The term "diorite" has not therefore been applied to these rocks.

A typical amphibolite (1536) from G.M.L. 541 (Hannan's Golden Dyke) at the northern end of the field appears in mass to

consist almost entirely of coarse crystals of dark green hornblende. Under the microscope the following minerals are recognisable:—

(1.) *Hornblende.*—Basaltic Hornblende: A considerable amount of brown, strongly pleochroic hornblende, scattered in small irregular grains throughout the section. These are evidently in most cases remnants of what were once large crystals, since groups of them are continuous in cleavage and optical properties.

Arfvedsonite occurs in apparently similar manner, but less frequently.

Common Hornblende—A pale green pleochroic hornblende is plentiful in large crystals, enveloping the basaltic hornblende. It is often fibrous in structure, and sometimes forms masses of interlacing needles. It is largely altered to chlorite, etc.

(2.) *Plagioclase.*—Fairly plentiful, entirely altered to saussurite. Some clear grains of what are apparently secondary albite are present.

(3.) *Ilmenite.*—Several irregular grains of ilmenite occur and a considerable amount of grey leucoxene, sometimes surrounding the former.

(4.) *Quartz.*—Some few clear grains, possibly quartz.

The example numbered 2117, the analysis of which appears in Table XVIII., is an extremely coarse grained grey-green rock, apparently wholly composed of hornblende, the microscopic characters of which are as follows:—

(1.) *Hornblende.*—As in 1536, basaltic hornblende and arfvedsonite are represented by a few irregular patches surrounded by large crystals of pale green common hornblende. The latter is of a fibrous nature and frequently occurs in bunches of fine fibres, and in fibrous extensions of the main crystals. Largely altered along cleavages to chlorite.

(2.) *Plagioclase.*—Represented by small patches of saussurite with occasional crystal boundaries. A little secondary albite present.

(3.) *Ilmenite.*—Largely altered to leucoxene.

(4.) *Quartz.*—None noted.

The greenish-grey rock numbered 3231, the analysis of which is given in Table XVIII., appears in hand specimens as a coarse-grained mixture of hornblende and felspar. Under the microscope its constituents are seen to be:—

(1.) *Hornblende.*—Large irregular crystalline masses with typical cleavage, and almost colourless; in places fibrous in structure and bordered by fibrous extensions. Several crystals show a single twinning. In places largely decomposed.

(2.) *Plagioclase.*—A considerable amount of saussurite embedded in a mosaic of clear albite, etc.

(3.) *Ilmenite.*—Frequent grains entirely surrounded by leucoxene.

A rock (1935) similar in appearance in hand specimens to the last, and collected on the Phœnix G.M.L. 2124E within the Kalgoorlie town boundaries, showed, in addition to the typical hornblende, felspar and ilmenite noted above, some less altered multiply twinned felspar and some areas of a micropegmatic intergrowth of quartz and felspar.

The microscopic examination of the amphibolites leads to some interesting conclusions. The most important constituent is found to be hornblende, sometimes as an original constituent, but usually possessing characteristics which point to its being of secondary origin, probably the result of the alteration of pyroxene. The presence of this secondary hornblende, the most entire conversion of plagioclase into the mixture of epidote, etc., known as "saussurite," and the very general conversion of ilmenite into leucoxene points to the fact that even these rocks, which are undoubtedly the least altered of the fundamental rocks of the district, have themselves been subjected to considerable physical and chemical metamorphism.

Following upon the molecular reconstruction evidenced in the amphibolites, comes a phase of chemical metamorphism, the influence of which is widespread but of varing intensity. Closely related to the amphibolites, and in places visibly merging into them, are a series of massive rocks characterised by a large development of chlorite. These rocks form the walls of the auriferous deposits of the Boulder belt, and have therefore been the subject of much investigation.

Both Göczel and Schmeisser, who were the first to critically examine these rocks, looked upon them as altered diabases of plagioclase—pyroxene rocks. In 1897 Mr. G. W. Card, Mineralogist to the Geological Survey of New South Wales, decided, as the result of an elaborate microscopic investigation, that these rocks were acidic porphyries, altered in various ways, notably by the introduction from surrounding basic rocks of chlorite and carbonates of lime and magnesia. This opinion was adopted by the author until the result of extensive chemical and microscopic examination, as well as investigation in the field, proved their identity with the previously described amphibolites.

The minerals which have been recognised in these rocks are hornblende, plagioclase, orthoclase, quartz, ilmenite and magnetite, all of which may be original constituents, or wholly or partially secondary, together with the undoubtedly secondary minerals chlorite, epidote, zoisite, sericite, leucoxene, rutile, calcite, dolomite, siderite, and pyrites, with occasionally löllingite, gold, etc.

These rocks are for the most part finely granular, the constituent minerals being only recognisable in hand specimens when they

occur porphyritically as all of them do on occasion. They vary in colour from grey-green to dark-green, and weather into more or less ferruginous clays.

The alteration which the amphibolites would seem to have undergone consists mainly of a conversion of hornblende and felspar, by the action of water and carbonic acid, into chlorite, epidote, and various carbonates, with the separation of free silica. The carbonate of magnesia is readily soluble in carbonated water, so that it is usually found that the more the rock has been affected by carbonic acid, the less magnesia it contains. Most of the pyrites has been formed at the expense of the iron silicates, since the more pyrites the rock contains the more bleached it appears, that is to say, the less unaltered iron silicates are left in it, the total percentage of iron in the rock remaining at the same time constant. This is well seen in specimens from Hannan's Reward G.M. Free silica would be liberated during the formation of both secondary carbonates and sulphides, which explains why, although the rock as a whole contains very little silica, a considerable proportion, at times, appears as free quartz. Finally, the ilmenite, which is so characteristic of this rock as of many basic eruptives, is almost wholly converted into leucoxene.

Analyses of several of these rocks appear in Tables XVIII. and XIX. under the title "Massive Greenstones." Neglecting 1936, which represents an intermediate stage between the amphibolites and these rocks, the average percentage of silica in twelve samples is 45·4, that of carbonic acid 9·4. Alumina and iron oxide (two of the less easily removed bases) are present in about equal proportions, which is extremely unusual in a rock of granitic affinities. In the percentage of these constituents as well as of silica, the rock resembles the amphibolites. Part of the lime, as well as the greater part of the magnesia, has been lost in solution, the underground waters of the district being very rich in both. (*Vide* analyses, page 45.)

The following are microscopic descriptions of typical samples of these rocks:—

1936. In hand specimens a coarse-grained mixture of chloritic material and felspar, from the 600ft. level, G.M.L. 2139E (Hannan's North), North end of Kalgoorlie Townsite, under the microscope shows:—

(1.) *Hornblende.*—Largely altered into scaly chlorite.
(2.) *Felspar.*—Both singly and multiply twinned. Largely altered into opaque grey decomposition products, and exhibiting beautiful micropegmatic intergrowths with quartz.
(3.) *Quartz.*—In addition to that intergrown with felspar, there are some large grains showing a very irregular boundary flanked by areas of scaly chlorite. This quartz would appear to be secondary.
(4.) *Ilmenite.*—Freely represented. Unaltered, except occasionally at the extreme edge.

De		Lode stuff (Chlorite Schist).		Massive Siderite Rock.	Foliated Siderite Rock.	Grey Schist.	
Geologic	6	1753	..	1751	1796	2817	..
evel, iew, ler.	117	400 level Ivanhoe G.M.L. 116 Boulder.	Winze, 200' level, Great Boulder G.M.L. 82 Boulder.	W. Cross-cut, 400', Ivanhoe G.M.L. 116, Boulder.	W. Cross-cut, 300' Golden Horseshoe G.M.L. 993, Boulder.	Winze, 200', Mt. Charlotte, G.M.L. 583, Kalgoorlie.	..
Sp	95	2·94	..	3·00	2·83	2·76	Sp. Gr.
, H_2O, Hygro	40	·09	..	·23	..	·29	H_2O
Combin	22	·30	..	·67	·13	1·08	H_2O
h, K_2O ..	37	2·57	2·25	1·15	1·47	1·54	K_2O
Na_2O ..	78	1·84	2·93	2·62	4·40	2·32	Na_2O
esia, MgO	18	3·56	4·97	1·67	·50	1·98	MgO
CaO ..	40	6·43	4·77	7·07	4·66	5·86	CaO
anous Oxide,	s.	·32	traces	·41	·77	·13	MnO
us Oxide, FeO	33	9·20	..	15·76	14·70	3·67	FeO
Oxide, Fe_2O_3	54	·33	18·98	2·45	4·02	..	Fe_2O_3
ina, Al_2O_3	55	12·49	9·67	8·42	11·46	12·93	Al_2O_3
s Copper, Cu		..	·14	..	..	..	Cu
Iron, Fe	99	1·05	4·80	·14	·09	..	Fe
Sulphur, S	42	1·20	5·49	·16	·10	..	S
n dioxide, CO_2	02	13·41	8·38	15·65	12·42	8·32	CO_2
um dioxide. T	23	·14	2·57	·81	·65	·33	TiO_2
SiO_2 .	27	46·94	35·04	42·61	44·96	60·73	SiO_2
	30	99·87	99·99	99·22	100·33	99·18	
Bases solu							
sia, MgO ..	02	3·56	4·87	1·67	·50	..	MgO
CaO ..	09	6·33	4·77	5·74	4·02	..	CaO
nous Oxide,	s	·32	traces	·41	·77	..	MnO
s Oxide, FeO	32	8·49	..	14·37	11·49	..	FeO
Oxide, Fe_2O_3	54	·33	17·84	2·45	4·02	..	Fe_2O_3
na, Al_2O_3	33	·31	6·62	·20	·39	..	Al_2O_3
Analyst	on.	C. G. Gibson.	Dr. Helms.	C. G. Gibson.	C. G. Gibson.	C. C. Williams.	..

Table XVIII.—*Analyses of Kalgoorlie Amphibolites and Derived Rocks.*

Description	Amphibolite.		Massive Greenstone.						Chlorite Schist.		Lode stuff (Chlorite Schist).			Massive Siderite Rock.	Foliated Siderite Rock.	Grey Schist.	
Geological Museum No.	3231	2117	1728	1729	1745	1800	1936	..	1730	1750	206	1753	..	1751	1796	2817	..
Locality.	Star of Colac G.M.L. 2872E, Boulder.	Main Shaft Gt. Boulder No. 2 South G.M.L. 1219E, Boulder.	Quarry, Central Boulder, G.M.L. 100, Boulder.	Railway Cutting Gt. Boulder Perseverance G.M.L. 194, Boulder.	220' level Boulder North Extended No. 3, G.M.L. 1285E, Kalgoorlie.	W. Cross-cut, 300', Golden Horseshoe G.M.L. 993, Boulder.	Main shaft, 600ft. Hannans North G.M.L. 673E Kalgoorlie.	Winze, 200' level, Great Boulder, G.M.L. 82, Boulder.	Main shaft, Imperial Boulder, G.M.L. 1222E, Boulder.	Waddington shaft, 400' Oroya G.M.L. 532E Boulder	300' level, Lake View, G.M.L. 117 Boulder.	400 level Ivanhoe G.M.L. 116 Boulder.	Winze, 200' level, Great Boulder G.M.L. 82 Boulder	W. Cross-cut, 400', Ivanhoe G.M.L. 116. Boulder.	W. Cross-cut, 300' Golden Horseshoe G.M.L. 993, Boulder.	Winze, 200', Mt Charlotte, G.M.L. 583, Kalgoorlie.	
Specific Gravity.	3·08	3·00	2·97	2·84	2·93	2·90	3·04	..	2·91	2·90	2·95	2·94	..	3·00	2·83	2·76	Sp. Gr.
Water, H_2O, Hygroscopic	·04	·22	·10	·11	·09	·05	·16	..	·27	·10	·40	·09	..	·23	..	·29	H_2O
Combined	1·51	4·25	2·00	1·83	1·26	1·83	1·51	..	1·74	2·30	·22	·30	..	·67	·13	1·08	H_2O
Potash, K_2O	·19	20	·56	·38	1·62	·76	·12	2·94	·26	·84	2·37	2·57	2·25	1·15	1·47	1·54	K_2O
Soda, Na_2O	2·58	1·02	2·66	3·17	1·97	3·40	3·92	2·46	3·04	3·17	1·78	1·84	2·93	2·62	4·40	2·32	Na_2O
Magnesia, MgO	7·65	11·42	4·38	4·26	1·87	·54	1·63	5·59	2·31	4·50	4·18	3·56	4·97	1·67	·50	1·98	MgO
Lime, CaO	12·19	10·43	8·24	8·86	6·23	4·18	5·05	8·20	7·52	14·72	6·40	6·43	4·77	7·07	4·66	5·86	CaO
Manganous Oxide, MnO	·90	1·60	traces	traces	·52	·38	·09	traces	traces	·21	traces.	·32	traces	·41	·77	·13	MnO
Ferrous Oxide, FeO	11·13	14·22	12·73	11·58	12·91	12·82	9·17	..	13·18	12·42	2·63	9·20	.	15·76	14·70	3·67	FeO
Ferric Oxide, Fe_2O_3	..	·13	4·47	4·35	·01	4·39	6·49	10·95	4·14	trace	1·54	·33	18·98	2·45	1·02	..	Fe_2O_3
Alumina, Al_2O_3	14·91	10·89	9·63	9·87	13·00	10·38	9·68	13·91	10·88	8·85	13·85	12·49	9·67	8·42	11·46	12·93	Al_2O_3
Pyrites: Copper, Cu	.	..	..	..	..	..	..	·05	..	..	..		·14	..	..	..	Cu
Iron, Fe	..	·12	·15	·11	·16	·10	..	·19	·16	·13	3·99	1·05	4·80	·14	·09	..	Fe
Sulphur, S	..	·14	17	·13	·18	·12	..	·22	·18	·16	4·42	1·20	5·49	·16	·10	..	S
Carbon dioxide, CO_2	nil	1·29	11·65	8·43	9·92	4·92	1·84	11·73	10·26	12·75	8·02	13·41	8·38	15·65	12·42	8·32	CO_2
Titanium dioxide, TiO_2	·22	·06	1·04	·64	·72	·62	1·13	·71	·63	·15	·23	·14	2·57	·81	·65	33	TiO_2
Silica, SiO_2	48·86	44·23	42·96	45·03	49·43	55·84	57·72	42·76	45·55	40·61	51·27	46·94	35·04	42·61	47·96	60·73	SiO_2
	100·18	100·22	100·74	98·75	99·89	100·33	98·51	99·71	100·12	100·91	101·30	99·87	99·99	99·22	100·33	99·18	
Bases soluble in Aqua Regia:																	
Magnesia, MgO		3·15	3·94	3·87	1·87	·54	1·63	5·35	2·08	4·50	3·02	3·56	4·87	1·67	·50	..	MgO
Lime, CaO		·59	8·24	8·85	6·07	3·98	3·34	8·20	7·28	8·86	6·09	6·33	4·77	5·74	4·02	..	CaO
Manganous Oxide, MnO	..	1·13	traces	traces	·52	·33	·09	traces	traces	·21	traces	·32	traces	·41	·77	..	MnO
Ferrous Oxide, FeO	.	5·00	10·25	10·08	12·45	11·79	8·42	..	10·50	7·53	2·32	8·49	..	14·37	11·49	..	FeO
Ferric Oxide, Fe_2O_3	..	·13	4·47	4·35	·01	4·39	6·49	9·69	4·14	..	1·54	·33	17·84	2·45	4·02	..	Fe_2O_3
Alumina, Al_2O_3	..	4·11	95	6·03	2·66	3·50	4·46	4·62	·78	·13	1·33	·31	6·62	·20	·39	..	Al_2O_3
Analyst	C. C. Williams.	C. G. Gibson	E. S. Simpson	E. S. Simpson	C. G. Gibson	C. G. Gibson	C. C. Williams.	Dr. Helms.	E. S. Simpson.	C. G. Gibson.	E. S. Simpson.	C. G. Gibson.	Dr. Helms.	C. G. Gibson	C. G. Gibson.	C. C. Williams.	..

TABLE XIX.—*Partial Analyses of Kalgoorlie Amphibolites and Derived Rocks.*

Description.	Foliated Amphibolite.	Massive Greenstone.							Foliated Greenstone.	Massive Siderite Rock.	Grey Schist.
Geological Museum No.	1954.	1754.	1755.	1757.	*1795.	1797.	1799.	1942.	1770.	1752.	1813.
Locality.	Commonwealth G.M.L., 3898E, Mt. Hunt.	East Crosscut, 500 feet, Ivanhoe G.M.L. 116, Boulder.	West Crosscut, 500 feet, Ivanhoe G.M.L. 116, Boulder.	West Crosscut, 200 feet, Ivanhoe G.M.L. 116, Boulder.	West Crosscut, 100 feet, Golden Horseshoe G.M.L. 993, Boulder.	North Crosscut, 100 feet, Golden Horseshoe G.M.L. 993, Boulder.	West Crosscut, 100 feet, Golden Horseshoe G.M.L. 993, Boulder.	North-East Crosscut, 500 feet, Lake View Extd. G.M.L. 273, Boulder.	West Crosscut, 500 feet, Great Boulder G.M.L. 82A, Boulder.	West Crosscut, 500 feet, Ivanhoe G.M.L. 116, Boulder.	Wild Cat G.M.L. 1042E, Boulder.
Specific Gravity	2·86	2·80	2·94	2·94	2·85	2·81	2·92	2·93	2·87	2·97	2·82
Soluble Iron protoxide, FeO...	2·86	8·33	17·01	13·81	7·35	6·59	12·48	8·71	4·47	12·86	4·35
Carbon dioxide, CO_2 ...	·91	7·45	10·08	9·29	9·23	7·27	8·30	14·68	9·26	15·58	11·30
Silica, SiO_2	44·25	47·19	41·43	33·97	45·09	47·36	47·06	36·59	46·61	42·20	54·45

* Partly weathered.

1728. A compact dark green rock, from the quarry on G.M.L. 100 (Central Boulder), Australia Hill, Boulder, shows under the microscope :—

(1.) *Chlorite.*—This is the chief constituent, and forms large areas of greenish scales, enclosing colourless or greyish masses of dolomite, etc.

(2.) *Felspar.*—Represented by well defined areas of an extremely fine-grained mosaic of secondary albite, etc.

(3.) *Quartz.*—Porphyritic grains with occasionally well defined boundaries, but more often filling irregular hollows in areas of chlorite. Irregular veins and scattered scales of chlorite frequently penetrate into the heart of the quartz grains, which would appear to be secondary.

(4.) *Ilmenite.*—Practically entirely altered to yellow opaque leucoxene. Large irregular grains are of frequent occurrence in the rock.

(5.) *Magnetite.*—Occurs in patches of small black grains.

1729. A specimen of the compact dark green rock, with small porphyritic grains of quartz and ilmenite, from the railway cutting on G.M.L. 194 (Perseverance G.M.), Boulder, presents a similar microscopic appearance to that of 1728. The boundaries of the previously existing crystals of hornblende and felspar are somewhat better defined. Quartz is more frequent, and appears as before, to be of secondary origin. Leucoxene enclosing skeletal triangles, etc., of the black unaltered ilmenite, is less frequent. A considerable amount of finely granular magnetite is present.

1745. A compact dark green rock, with occasional porphyritic grains of quartz from the 320ft. level, G.M.L. 1285E, between Kalgoorlie and Boulder, shows chlorite and felspathic mosaics as in the previous specimens. Coarsely granular calcite visible with characteristic cleavage. Quartz frequent, but in smaller grains, and largely micropegmatic. Ilmenite (mostly unaltered), magnetite, and pyrites are present.

1800. The compact dark green rock, with porphyritic grains of quartz and ilmenite, showing in the 300ft. level, G.M.L. 993 (Golden Horseshoe G.M.), Boulder, presents similar characteristics to 1745, the quartz being in this case also largely micropegmatic, a structure, due apparently to an intergrowth of secondary silica and chlorite, since it is this latter mineral, and not felspar, with which the quartz is associated.

The "Greenstones" have been subjected to considerable pressure and shearing, and have been in places foliated with the production, in extreme cases, of Chlorite Schists. These rocks vary in colour from grey to dark green, and by virtue of their foliation have formed channels in the more massive rocks for the free circulation of mineral solutions. In some cases their composition is identical with that of the greenstone from which they are derived, as is shown by analyses 1730, 1750, and 1753, Table XVIII.

Where the free circulation of mineral solutions has resulted in the deposition of free gold and gold tellurides, these foliated bands in the greenstone becomes more or less well defined ore deposits, and constitute the productive "lode formations" of the Kalgoorlie field. This has usually been accompanied by the removal of portion of the iron present, and a conversion of more or less of the remainder into pyrites. (*Vide* 206, and 1753, Table XVIII.)

The following are descriptions of the rocks analysed:—

1630. A greenish-grey foliated rock, showing scales of green chlorite on the foliation planes from G.M.L. 1222E, close to the Lake View Suburban Area. It is seen under the microscope to consist mainly of scaly chlorite and a finely granular felspathic material with parallel arrangement. Embedded in this are numerous crushed grains of ilmenite partly altered to leucoxene, some calcite, and some grains of quartz, with typically irregular outline.

1750. The dark green foliated rock, from the 400ft. level of G.M.L. 532 (Hannan's Oroya, G.M.), Boulder, presents similar microscopical characteristics to 1730 with the exception that quartz is almost absent, and there are a considerable number of areas of a greyish mineral which, under crossed nicols, appears as a mosaic of blue-grey and white.

206. A strongly foliated grey "lode stuff" from the 300ft. level of G.M.L. 117 (Lake View Consols G.M.), Boulder, assaying 9oz. 12dwts. 18grs. of gold, and 6oz. 7dwts. 8grs. of silver per ton. It shows chlorite and sericite on the cleavage planes.

1753. A foliated greenish-grey lode stuff from the 400ft. level, G.M.L. 116 (Ivanhoe G.M.), Boulder, is exactly similar to 1750, under the microscope, except that quartz is developed on a larger scale.

Some of the chlorite rocks have lost a considerable portion of their iron and magnesia, and had the balance converted into carbonates, with the production of a massive or foliated grey rock carrying somewhat more silica than the other associated rocks. Analysis 1813, Table X1X., represents a very compact grey foliated rock which, under the microscope, is seen to consist of a minutely granular base studded with numerous greyish scales which may be kaolin, and some grains of calcite, quartz, and ilmenite.

An interesting modification of the amphibolite occurs in the Ivanhoe and adjacent mines. In certain bands of the rock there, the whole of the iron, lime, and magnesia has combined with carbonic acid to form a rock rich in siderite and other carbonates. This rock is sometimes massive, sometimes foliated, analyses of both varieties appearing in Table XVIII., Nos. 1751, and 1796.

Specimen No. 1751, from the Ivanhoe G.M., Boulder, is a light grey compact rock, exhibiting porphyritic grains of quartz and of black iron ores. In outward appearance, it is identical with a quartz porphry, but effervesces freely with acid, and, on analysis, is

found to contain 38 per cent. of carbonates of iron, etc. Under the microscope, it is possible to detect numerous crushed grains of ilmenite, more or less altered to leucoxene; quartz, in crushed and uncrushed grains, as well as in areas of micropegmatite; carbonates in irregular veins and grains; altered felspar, represented by areas of a minute mosaic; some scaly green chlorite; finally, associated with the chlorite, large aggregates of greyish or colourless scales similar to those described in specimen 1813.

A second specimen (1828) of a rock of this nature, from Chaffer's G.M., differed only from the last in containing more chlorite, closely associated, as before, with the grey scaly matter, and a considerable amount of magnetite, formed apparently at the expense of the ferrous carbonate.

In the Golden Horseshoe G.M. is a rock (1796) similar in composition to the last two described, as its analysis in Table XVIII. shows, but foliated. Silvery sericite is developed on the foliation planes. Under the microscope the rock appears of identical constitution to No. 1751.

Summing up the available information with regard to the Amphibolites and their Derivatives, as described above, it appears that:—

1. All these rocks are portions of the one mass, and have originally been one and the same. No remnants of that original rock being left unaltered, its exact nature cannot be determined. That it was an igneous rock appears certain from the presence of ilmenite, hornblende, and areas of micropegmatite, and from the absence of fossils or water-worn inclusions. It may have been a diabase or plagioclase-augite rock.

2. The original rock has been metamorphosed in three ways: By molecular rearrangement, with the production of secondary hornblende. Mechanically, many of the minerals being fractured or crushed, and more or less foliation set up. Chemically, by the absorption of water, carbonic acid, sulphur, etc., resulting in a complete destruction of original minerals and the formation of secondary chlorite, calcite, quartz, etc.

3. The so-called "lode formations" are in most cases merely bands of this igneous rock which have been permeated by solutions of the precious metals.

(2.) Newer Eruptives.

Traversing the main mass of amphibolite and older sediments are several intrusive masses of felspar-porphyry, porphyrite, and peridotite.

Felspar Porphyry.—The only acidic intrusives observed have been of this type, analyses of which are given in Table XX.

TABLE XX.—*Analyses of Kalgoorlie Porphyries.*

Geological Museum No.	2219.	1435.	1980.	1743.
LOCALITY.	700ft. level G.M.L. 749, Brookman's Boulder Gold Mine, Boulder.	500ft. level G.M.L. 749, Brookman's Boulder Gold Mine, Boulder.	150ft. level G.M.L. 1226E, Hannan's Hundred Acres Gold Mine, Boulder	Main Shaft G.M.L. 1064E, Boulder Bonanza Gold Mine, Boulder.
Specific Gravity.	2·72	2·70	2·72	2·60
Water, H_2O, Hygroscopic	·07	...	·07	·17
Do. Combined ...	·25	...	·46	·29
Potash, K_2O	1·59	3·33	3·28	1·29
Soda, Na_2O	6·18	2·31	4·27	6·03
Magnesia, MgO	1·32	...	·38	·92
Lime, CaO	4·03	...	2·10	·71
Manganous oxide, MnO ...	·51	...	·05	Trace
Ferrous oxide, FeO ...	3·03	...	2·39	2·27
Ferric oxide, Fe_2O_3 ...	·39	...	Trace	1·09
Alumina, Al_2O_3	14·98	...	18·12	15·97
Pyrites { Iron, Fe ...	·28	...	·03	Trace
Pyrites { Sulphur, S ...	·32	...	·03	Trace
Carbon dioxide, CO_2 ...	5·65	4·44	2·41	1·13
Titanium dioxide, TiO_2 ...	·16	...	Trace	·62
Silica, SiO_2	62·16	70·60	65·51	68·12
	100·92	...	99·10	98·61
Bases soluble in Aqua Regia				
Magnesia, MgO	1·32	...	·38	·58
Lime CaO	4·03	...	1·99	·35
Manganous oxide, MnO ...	·51	...	·05	Trace
Ferrous oxide, FeO ...	3·03	1·48	1·73	2·27
Ferric oxide, Fe_2O_3 ...	·39	...	Trace	1·09
Alumina, Al_2O_3	·58	...	·46	·31
Analyst	C. G. Gibson	C. C. Williams	C. G. Gibson	E. S. Simpson

No. 2219 is a very dense reddish rock, carrying reddish porphyritic crystals of orthoclase, and exhibiting scales of chlorite and sericite on the cleavage planes. It is from the eastern edge of a dyke, of the centre of which No. 1435 is typical, and has evidently been altered somewhat by the passage into it of solutions from the adjacent greenstones carrying soda, lime, etc. Under the microscope it is seen to consist of a minutely granular base of felspar, calcite, etc., in which are embedded numerous porphyritic crystals of orthoclase, together with a little plagioclase, chlorite, and iron ores.

No. 1435 is a white foliated rock from the same dyke. Numerous porphyritic crystals of felspar are scattered through a

dense greyish-white base. Sericite is freely developed on the cleavages. Except for the absence of chlorite its microscopic characters are similar to 2219.

No. 1980 is a dense greenish-grey rock with porphyritic crystals of felspar.

No. 1743 is obviously somewhat weathered. It is a dark grey rock with milky white porphyritic felspar crystals.

Porphyrite.—Underlying the flats to the west of Kalgoorlie and Boulder there is a considerable area of a massive rock, which appears to be an intrusive porphyritic diorite. It is typically a dark brownish-green rock, with numerous white porphyritic crystals of felspar. Porphyritic hornblende crystals are also frequently discernible. In places, as for instance on G.M.L. 2266 (Buttercup Extended), to the south-west of Boulder, the rock becomes so fine-grained as to lose its typical porphyritic appearance, except when viewed through a lens. At other times, as on G.M.L. 3661E (Joy), the rock exhibits a peculiar mottled appearance: certain portions are typically coarse-grained in felspar and hornblende, adjacent portions are extremely fine-grained, and within these again are areas more or less sharply defined of pale grey felsite-like rock. This structure may be allied to the well-known orbicular structure, and be due to irregular crystallisation of the component minerals. Of a similar nature, probably, is the peculiar structure observed in this rock on Water Reserve 3398. The porphyrite there encloses spherical masses from one to three, or more, inches in diameter of a reddish or pale grey porphyrite somewhat similar to the enclosing rock, but often separated from it by a thin layer of chloritic material, which enables the inclusion to be broken out as clearly from the rest of the rock as a water-worn pebble from a sediment.

A typical porphyrite (2943) from 200 feet in the main water shaft on Water Reserve 3398, immediately West of Kalgoorlie, was found to have the following composition:—

Water, H_2O Hygroscopic	·04
,, ,, Combined	·26
Potash, K_2O	·62
Soda, Na_2O	6·74
Magnesia, MgO	1·58
Lime, CaO	5·92
Manganous oxide, MnO	·02
Ferrous oxide, FeO	5·36
Alumina, Al_2O_3	14·04
Carbon dioxide, CO_2	1·47
Titanium dioxide, TiO_2	·97
Silica, SiO_2	63·05
	100·07
Specific Gravity	2·75

Analyst, C. C. Williams.

Under the microscope the rock is seen to consist of a finely granular base, in which are embedded numerous porphyritic crystals of decomposed felspar, numerous irregular fragments of olive-green hornblende, and in addition some scattered grains of iron ores and some calcite.

Peridotite.—On the West shore of Hannan's Lake there is a large outcrop of a rock, which in its least altered condition is black in colour and very fine grained, and is composed mainly of olivine, with subordinate augite and a little glass. It would appropriately be termed an augite-peridotite. Like most peridotites it is largely represented by alteration products, having been in many places as on G.M. 3517E (Sweet Marie), converted into a solid serpentine-rock. Lamellar and fibrous serpentine (asbestos) are found associated with it in places. On a small island near the West shore of the lake a most interesting modification is to be seen. Here the peridotite has been completely altered by the agency of carbonated waters into a coarsely crystalline rock of a dark grey colour, dotted with numerous light brown crystals. It is composed largely of carbonates of magnesia, lime, and iron.

The following are analyses of typical specimens of these rocks:—

G.S.M. No.	3,218	375	1,472	1,462
Specific Gravity	2·81	2·89	2·80	2·85
Silica, SiO_2	39·35	31·07	34·17	34·32
Titanic oxide, TiO_2	·60	·26	...	...
Alumina, Al_2O_3	6·56	5·49	...	...
Ferric oxide, Fe_2O_3	...	1·49	...	...
Ferrous oxide, FeO	9·45	7·64	...	...
Manganous oxide, MnO ...	1·57	·18	...	...
Lime, CaO	3·10	5·46	...	...
Magnesia, MgO	28·51	17·49	...	...
Potash, K_2O	·15	·11	...	...
Soda, Na_2O	·73	3·82	...	...
Iron, Fe	...	·03	...	...
Sulphur S	*Nil.*	·03	...	...
Carbonic anhydride, CO_2 ...	*Nil.*	27·24	19·90	24·92
Water, H_2O, hygroscopic ...	·14	·07	...	...
Water, H_2O, combined ...	9·05	·05	...	...
	99·21	100·43	...	...
Analyst ...	C. C. Williams.	C. G. Gibson.	C. C. Williams.	C. C. Williams.

No. 3,218.—A dense black brittle rock, with conchoidal fracture, from M.L. 13E, consists mainly of granular hydrated olivine, with subordinate augite, yellowish glass, and iron oxides.

No. 375.—Coarsely granular crystalline rock from island on West of Hannan's Lake.

No. 1,472.—Brown granular rock resulting from partial weathering of 375.

No. 1,462.—Granular black rock, with brownish crystals, from second island, near 375.

(3) Older Sediments.

Surrounded on all sides by the igneous rocks, and dipping at a high angle, are a series of sedimentary rocks, ranging on the one hand from a soft shale to a jasperoid slate, and on the other from a sandstone to a flinty quartzite. The effect of metamorphism on these rocks has been as varying in its intensity as on the amphibolites. Soft grey shales and ironstones pass into fine grey or graphitic slates, in which secondary silicification has sometimes gone on up to the point of converting the rock into an opaque banded jasper. Graphite to the extent of 5 per cent., or more, is a frequent constituent in the slates. It may owe its origin to the alteration of organic matter originally existant in the rocks, or to the subsequent intrusion of vapours of hydrocarbons into the beds.* A peculiar feature of the graphitic slates are spherical nodules of pyrites from $\frac{1}{8}$ inch up to an inch or more in diameter, which are frequently enclosed in them. In Walsh's Quarry on M.L. 58E, the slates have been baked into a porcellanite by an intrusive dyke, now too far decomposed for its original character to be determined.

Of siliceous sediments, soft sandstones are of rare occurrence, but narrow bands of sandy material do occur with the shales. Flinty quartzite is of frequent occurrence, ranging in composition from almost pure silica, to various mixtures of quartz, clay, and iron oxides, the latter, however, being seldom found in notable quantities.

Breccias occur in several parts of the field. Near M.L. 50E, Hannan's Lake, there is a quartz breccia (3202) which, by secondary silicification, has been hardened into a flinty quartzite. Between the Trafalgar Townsite and Hannan's Lake, on G.M.L. 1879E (Hannans Gold Estates), there is a breccia (1726) composed of coarse fragments of slate, set in a base composed of quartz, crushed slate, etc.

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* Mr. W. D. Campbell's investigations in the field point to the possibility of some of these graphitic rocks being foliated greenstones.

The following are analyses of three of these rocks :—

Geological Museum No. ...	1732	1731	1739
Specific Gravity	2·73	2·66	2·71
Water, H_2O Hygroscopic ...	·42	·20	·15
„ „ Combined ...	1·34	1·05	1·65
Potash, K_2O	1·28	2·21	1·85
Soda, Na_2O	3·46	1·64	2·79
Magnesia, MgO	·12	·24	1·69
Lime, CaO	·14	·21	5·86
Maganous oxide, MnO ...	Trace	Trace	·09
Ferrous oxide, FeO	·87	·45	1·65
Ferric oxide, Fe_2O_3	1·00	·42	·54
Alumina, Al_2O_3	15·22	9·03	17·82
Pyrites ... { Copper, Cu ...	·50	...	...
Pyrites ... { Iron, Fe ...	2·47	·02	·88
Pyrites ... { Sulphur, S ...	2·96	·02	1·00
Carbon dioxide, CO_2	·02	·07	5·50
Titanium dioxide, TiO_2 ...	·34	1·16	·05
Silica, SiO_2	70·25	84·07	60·01
	100·39	100·79	101·53
Analyst	E. S. Simpson	E. S. Simpson	C. G. Gibson

No. 1732. Dark grey sandstone from G.M.L. 917E, Paringa Consolidated Mines, Ltd., Boulder.

No. 1731. Dark grey slate from the same lease.

No. 1739. Light grey sandstone from the 400ft. level G.M.L. 3625E, Hawk's View G.M., Kalgoorlie. A slightly foliated rock, in which the only minerals visible to the naked eye are pyrites and a bright green scaly mineral associated with it. In one specimen (1739) a well rounded quartz pebble, an inch in length, occurs embedded in the rock, pointing to the sedimentary origin of the latter.

(4.) Newer Sediments.

These are of two kinds, Chemical and Mechanical. The former includes Salt, Travertine, Siliceous Sinter, and Laterite; the latter, Sand, Clay, and Ironstone Gravel.

Salt.—All the underground waters of the district carry salt in solution, and more or less occurs in the surface waters which occasionally cover the clay pans, so that on evaporation a thin crust of salt is left on the surface of the soil. This never appears to be more than about one-tenth of an inch thick.

Travertine.—Porous travertine of a yellowish colour and consisting largely of carbonate of lime with some admixed sand, iron oxide, etc. Small irregular beds of this occur on the surface near

Hannan's Lake, but its most interesting occurrence is in the form of a thin continuous layer at a depth of from a few inches to six or eight feet below the surface in the alluvial ground. In all cases the ultimate origin of the carbonate of lime is the basic igneous rocks of the district, its deposition being due to the evaporation of waters carrying it in solution.

Siliceous Sinter.—On G.M.L. 1860E (Oxley), near Hannans Lake, there is a deposit of siliceous sinter. It varies in character from a light porous white rock composed almost wholly of silica to a dense brown rock containing a considerable proportion of iron oxide. It is studded with irregular lumps of transparent opal, which, on weathering, gradually become opaque and white in colour like the granular mass in which they are mostly imbedded. This change begins at the outside of the lumps and gradually penetrates to the centre, and is probably due to a loss of water, by which the dense transparent opal becomes porous and opaque.

Laterite.—The crests of many of the hills and ridges about Kalgoorlie are composed of a rock consisting mainly of hydrated iron oxide, for which the term "laterite" seems most applicable. The following are analyses by Mr. J. H. Brooking of two typical specimens from the railway cutting on Quarry Reserve 6653, one mile North-East of Kalgoorlie:—

	1937.		1938.
Water, H_2O, Hygroscopic ...	·52	...	·63
Do. do. Combined ...	8·10	...	10·84
Ferric oxide, Fe_2O_3	82·33	...	67·74
Alumina, Al_2O_3	(7·52)	...	(16·72)
Silica, SiO_2	1·53	...	4·07
	100·00	...	100·00

No. 1937 is a dark brown ironstone of a somewhat concretionary character, with irregular patches of light brown material, which is probably ferruginous bauxite. There are numerous small irregular holes in the rock.

No. 1938 is a mottled brown ironstone composed of irregular patches of pure iron ore, and of yellow bauxite in a reddish-brown base. It would appear as if the iron ore had been cemented together by this base, and the unfilled hollows then filled with bauxite. There are practically no visible pores in this rock.

A sample (2843) from the top of Lone Hill on G.M.L. 3450E, Kalgoorlie, consists of practically pure compact iron ore of a dark brown colour and of a brilliant lustre. Numerous irregular hollows occur in the rock.

In composition the laterites are found to consist of more or less pure hydrated iron oxide, varying between turgite and limonite.

The chief remaining constituent is hydrated alumina or bauxite, silica being almost absent. An examination in the field shows that these rocks overlie chlorite schists or other highly ferruginous igneous rocks, and it would appear that they owe their origin to the solution of the ferrous oxide in these rocks in rain water, which subsequently is drawn to the surface by capillary attraction, where the iron is precipitated as ferric oxide on evaporation of the water. One naturally expects more or less alumina and silica to accompany the iron in solution. This theory is supported by the fact that drives beneath the laterite on G.M.L. 1007E show that immediately below it the greenstone has lost all its iron oxide and been converted into a white or yellowish clay which, near the surface, is traversed by numerous veinlets of iron ore.

Sand and Clay.—Deposits of these of the usual type, though usually ferruginous, are of considerable extent, and are frequently auriferous.

Ironstone Gravels.—The denudation of laterites and other ferruginous rocks gives rise to deposits of rounded pebbles of iron ore which are often cemented together by iron oxide, and are then with difficulty distinguished from true laterites.

OBSIDIANITES.*

These most interesting objects of mysterious origin are of frequent occurrence throughout the Eastern Goldfields of the State. A paper describing their occurrence elsewhere in Australia, was read before the Royal Society of Victoria in 1898, by Mr. R. H. Walcott, F.G.S., who discussed at length the theories as to their genesis. The following remarks apply to those West Australian specimens which have been examined by the author.

Obsidianites may be described as small objects composed of a homogeneous glass akin to obsidian, and usually of certain symmetrical forms closely related to those assumed by a plastic projectile in its passage through the air. They have been called "Emu-stones" in this State, for what reason the writer has been unable to ascertain.

Locality.—All the West Australian obsidianites have been found on the surface, or within a few feet of it, in the recent superficial deposits. They have been recorded from Albany, Lake Cowan, Lake Lefroy, Slate Well, Coolgardie, Kalgoorlie, Kanowna, Bulong, Kurnalpi, Menzies, Mt. Margaret, and a point 100 miles East by South from Weld Springs.

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* The author is indebted to Mr, W. D. Campbell for the kind loan of his collection during the revision of this article.

Composition.—The following is the analysis of a broken obsidianite from Kalgoorlie, weighing 3·5 grammes :—

Silica, SiO_2	71·65
Alumina, Al_2O_3	11·96
Ferric oxide, Fe_2O_3	6·62
Manganous oxide, MnO	·16
Lime, CaO	3·03
Magnesia, MgO...	2·09
Potash, K O	2·40
Soda, Na O	1·76
	99·67
Specific gravity...	2·47

In chemical composition this specimen agrees with those found in Victoria, New South Wales, and Central South Australia, as well as those from Billiton and other islands of the East Indies. It is identical with that of ordinary obsidian of undoubted volcanic origin.

By reflected light obsidianities appear black and opaque; by transmitted light in thin flakes they are transparent, varying in colour from greenish-brown in the thicker parts to brownish-yellow in the thinner. The glass is perfectly homogeneous to the naked eye, but under the microscope shows a faint streakiness. No crystallites or other signs of devitrification have been observed in the two bombs of which thin sections were cut.

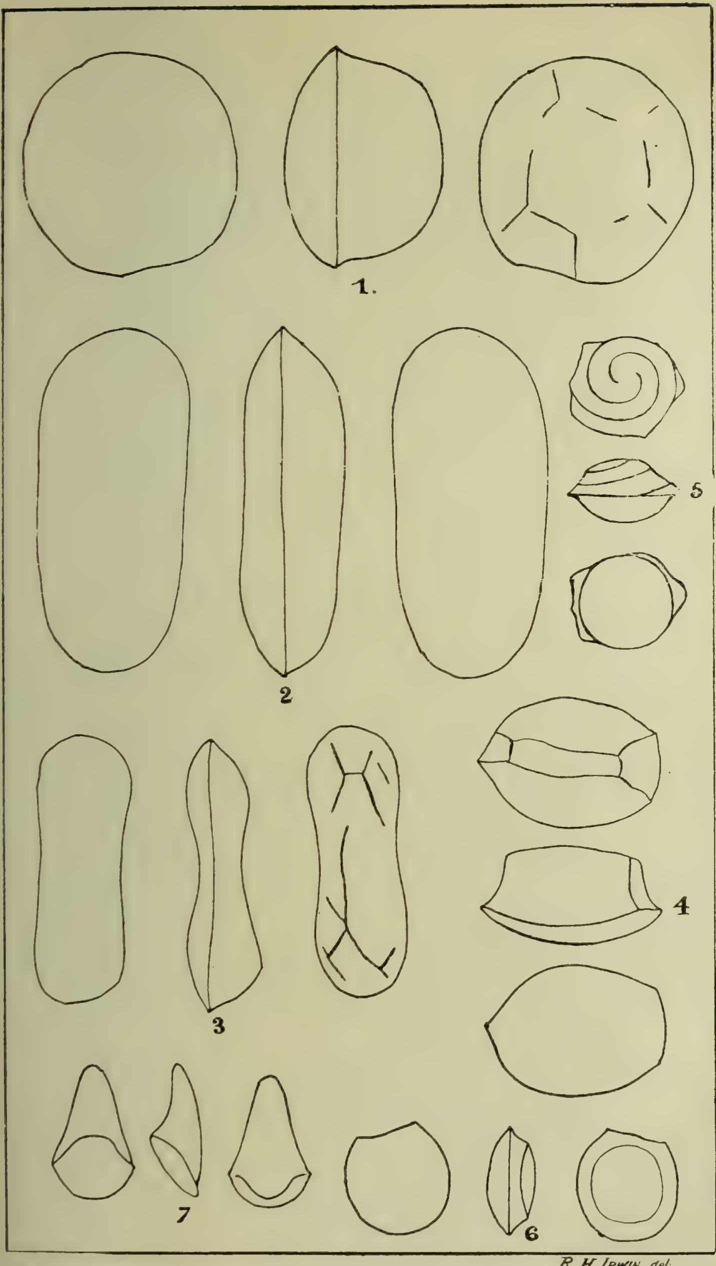
Specific Gravity.—In 10 specimens this varies from 2·42 to 2·49, the mean being 2·448. Individual values are given below.

Shape.—By far the greater number of the specimens examined were enclosed by two unequally convex curved surfaces meeting in a clearly defined median line or equator, others being of various irregular forms.

Several typical forms are illustrated in the accompanying plates. They are of six main types, viz.:—

(1.) Circular Lens. Figures 1, 5, 6, Plate VI. The surface of this, the commonest of all forms, consists of portions of two spheres of unequal radius, a form natural to a plastic projectile. The under, or more convex side, generally curves outwards slightly just at the junction with the other side (Figures 1 and 6). This is less frequently the case with the upper or less convex side (Figure 5).

(2.) Oval Lens. Figure 2, Plate VI. This form is similar to the last except that the upper and lower surfaces are formed of two ellipsoids, thus giving the equator an elliptical instead of a circular outline.



W.A. Newspaper Co.

PLATE VI.—OUTLINES OF TYPICAL OBSIDIANITES FROM THE EASTERN GOLDFIELDS OF W.A.

Scale of Nature.

(3.) Double-headed.—Figure 3, Plate VI. This differs from the last in having at the centre a "waist," thinner and narrower than either end. The equator is usually very sharply defined, *vide* Plate 8.

(4.) Kernel-shaped.—Figure 4, Plate VI. Formed like the other types of two unequally convex surfaces, the outline of the equator however is curved at one end and comes to a sharp point at the other. Two such forms would probably be produced from a double-headed obsidianite if it remained plastic sufficiently long for the two ends to be drawn completely apart under the influence of the centrifugal force. There is often considerably more difference in the convexity of the two sides of this form than the others, *vide* Fig. 1, Plate VIII.

(5.) Top-shaped.—In this variety the upper surface is hemispherical, the lower conical. Figure 7, Plate VI., illustrates an obsidianite in Mr. W. D. Campbell's collection, in which the conical portion has been bent over to one side and slightly flattened.

(6.) Pencil-shaped.—A more uncommon form than the others. It is cylindrical in cross sections, being devoid of any "equator," and terminates in a sharp point at each end.

In addition to these well defined forms obsidianites are found at times of various irregular shapes, often the result apparently of spontaneous flaking of more regular bodies.

Size.—Obsidianites vary considerably in size. The largest observed is shown in Plate I. It is lens-shaped, and was found 100 miles East by South of Weld Springs, or say about Lat. 25° 30′ S. and Long. 123° 0′ E. Its total weight was 116·1 grammes, and it measured 56 x 54 x 31 millimetres. A large flake had been broken off one side by the finder, so that its original weight must have been 120 grammes at least. The smallest observed was of the "kernel" type, and came from Red Hill, near Lake Lefroy. Its weight was 0·5 gramme, and it measured 11 x 8 x 5 millimetres. The largest oval obsidianite seen is in Mr. Campbell's collection, and came from Red Hill. It weighed 33·7 grammes, and measured 59 x 24 x 15 millimetres.

Surface Features.—The surface of the freshest bombs have a brilliant black lustre, making them appear, as Krause says,* as if varnished or lacquered. The majority however have been roughened and dulled by wind-blown sand. The sculptural features of the surface are of two kinds, those apparently produced whilst the substance was still plastic, and those probably produced after its solidification.

* P. G. Krause, "Obsidianbomben aus Niederlandische Indien." Sammlungen des Geologischen Reichs-Museum in Leiden. Ser. 1, Band V.

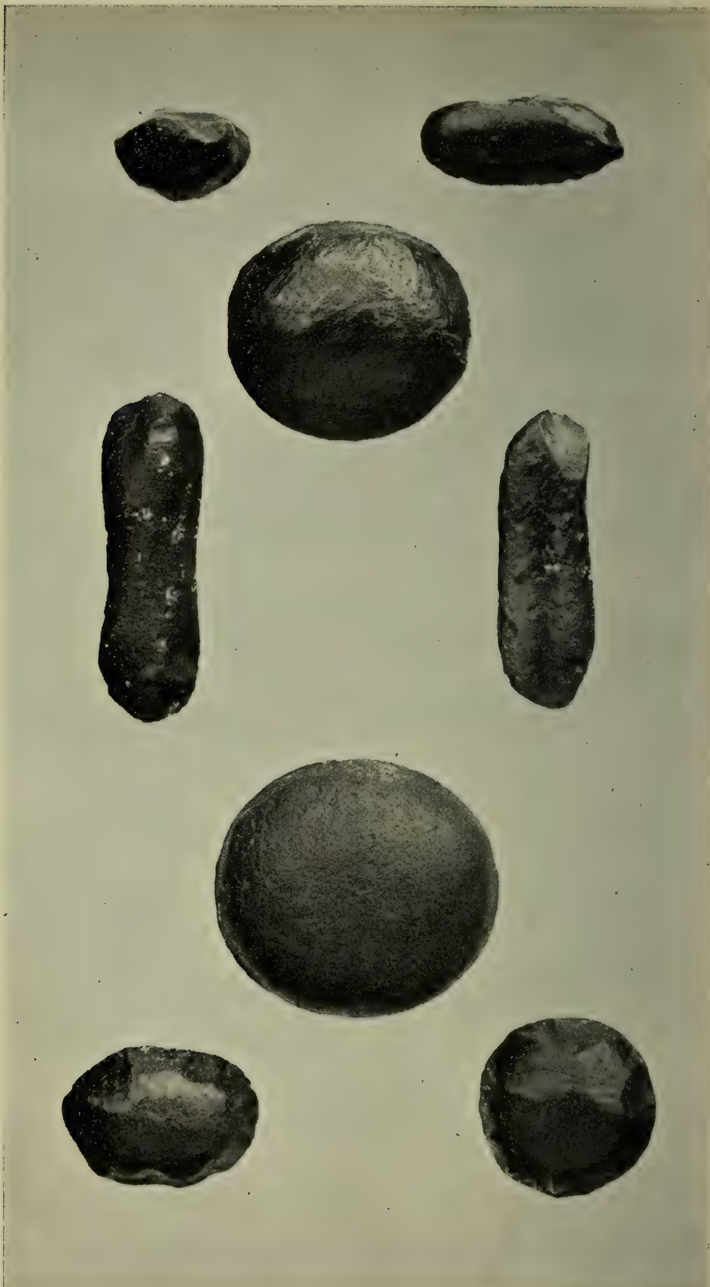


PLATE VII.—WEST AUSTRALIAN OBSIDIANITES: VIEW OF UNDER SURFACE.
Scale of Nature.

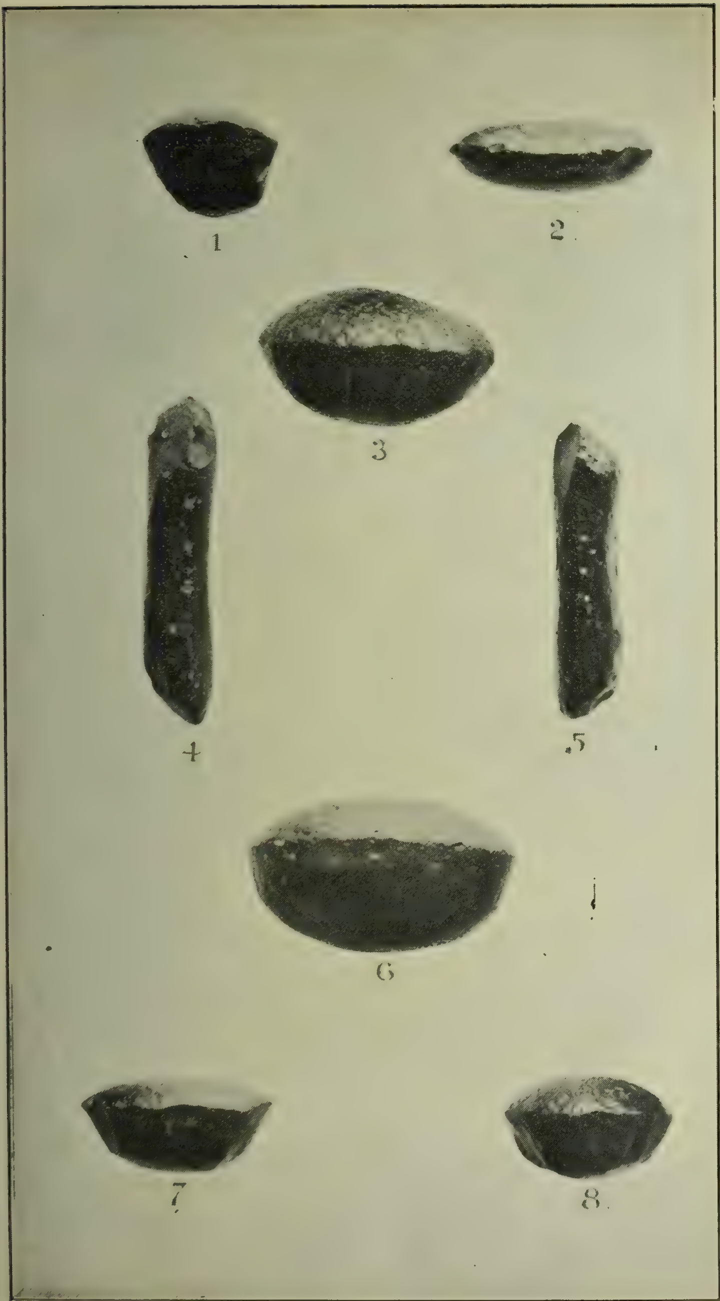


PLATE VIII.—WEST AUSTRALIAN OBSIDIANITES: SIDE VIEW.
Scale of Nature.

Closely related to these are certain cylindrical hollows, or flutings, remarkable, as pointed out by Krause, for the slight wrinkles which cross them at right angles and give them the appearance of having been gouged out in a series of jerks. This appearance, however, is characteristic of all conchoidal fractures. These cylindrical hollows run in either straight or curved lines, occasionally curving sharply round to form a horseshoe or circle. On the upper surface of the specimen marked 8, in Plate VIII., there are a number of these small channels. Several are plainly visible in Fig. 2, Plate I. An exactly similar fracture of the surface was accidentally produced by a slight knock against one of these obsidianites.

On the upper surface of a bomb in the collection of the Perth Museum, as well as one or two others, there is a series of hollows quite distinct from those described. They are wedge-shaped cuts, from 2 to 5 mm. long, and 1 to $2\frac{1}{2}$ mm. deep, and are arranged radially, or almost so, as shown in Fig. 1, Plate I. They are not very numerous near the equator, but towards the centre are so thick as to practically obliterate the whole of the original surface there.

Finally, in many specimens there are rough, irregular fractures produced by the solidified bomb striking against a rock on falling, or still more recent ones made by prospectors, amongst whom, unfortunately, the impression prevails that these objects frequently surround a core of gold.

Age.—Some obsidianites present such a glossy, unweathered surface that they cannot be more than a few years old. The majority, though their surfaces are roughened by sand, are otherwise unaltered, and cannot, therefore, be very much older. Some few, however, are considerably weathered. None have been found at a greater depth than a few feet below the present surface. The evidence, therefore, points to their being of very recent geological age.

Origin.—The origin of obsidianites has been a subject of discussion for many years, and is still unsettled. The facts are that although they resemble bombs of volcanic origin, no volcano emitting lava of this description is known anywhere in Western Australia or elsewhere where these objects are found, except in Java, whilst the greatest distance to which an active volcano has ever been known to hurl bombs is only about 80 miles.

Four origins are suggested for these objects, (1) meteoric, (2) lunar volcanic, (3) terrestrial volcanic, and (4) artificial.

There are two objections to considering obsidianites to be meteorites, viz., their composition, which differs from all other meteorites; and secondly, their regular rounded form, since, on reaching the earth a meteorite would be white hot, and if of this composition, thoroughly molten, so that it would be completely shattered, or, at least, flattened out into a thin sheet. The only argument in support of a meteoric theory of origin is their wide distribution.

The same remarks apply also to the theory of their derivation from lunar volcanoes. Further, it is impossible to imagine any volcano throwing out a mass of lava to such a height that the attraction of the earth would be greater than that of the moon, from which it was derived. To do this, the bomb would have to reach a height of something like 28,600 miles above the moon's surface, even if ejected in the direction of the earth.

There only remain the theories of terrestrial volcanic and artificial origins, the latter of which may be dismissed as quite untenable. With regard to the former, the only objections raised against it are the wide distribution of obsidianites over areas hundreds of miles from any volcano capable of producing them, their usual lack of internal vesicles, and, finally, the very regular shape of many of them. In the last two respects they certainly do differ somewhat from most authentic bombs of similar composition. With regard to the former, there are two possible sources of obsidianites, viz., the volcanoes of the North Island of New Zealand and those of the East Indies, more particularly Krakatoa. No similar bombs, however, are known in New Zealand, while a considerable number are recorded from the East Indies, which points to the latter being the source from which they are derived. The point nearest to Java from which obsidianites are recorded in Australia is about 1,000 miles from the volcano of Sumbawa, and 1,500 miles from Krakatoa; the most remote is 3,500 miles from the latter.

It has been suggested that they have been distributed by the aborigines. Some tribes certainly look upon them as charms, but the majority apparently of the present race of blacks set practically no value upon them, so that it would seem that in most cases their present location is not due to the aborigines. We are therefore obliged to fall back upon air-currents to explain their distribution. Geikie, speaking of volcanoes in general, says: "Instances are "known where large stones, ejected obliquely, have described huge "parabolic curves in the air, and fallen at a great distance. . . "One of the most stupendous volcanic explosions on record was that "of Krakatoa in 1883. . . . A mass of matter, estimated at "about $1\frac{1}{8}$ cubic miles in bulk, was hurled into the air in the form "of lapilli, ashes, and the finest volcanic dust. . . It was esti-"mated that the clouds of fine dust were hurled from that volcano "to a height of 17 miles." The more solid bombs would, therefore, reach to at least three times that height, possibly ten times or more, as can be proved by experiment. It is utterly impossible in our present state of knowledge to definitely affirm such a statement, but it certainly appears within the realms of possibility that, aided by the strong southward current in the upper regions of the atmosphere, small bombs might be hurled to a distance of several hundreds of miles under these conditions. It is at least more easy to believe this than that lunar volcanoes would hurl the same objects to a height of over 28,000 miles.

If obsidianites are in reality terrestrial volcanic bombs, we may imagine their life history to be somewhat as follows:—Originally part of an intensely hot fluid lava, they were hurled out by the force of some gigantic explosion, for the most part receiving a certain rotatory motion at the same time in a plane at right angles to the direction of their flight. Although at first more or less vesicular, their high temperature, maintained for some time by the rapidity of their flight, permitted all the gas and steam to escape from them. As the speed of their flight slackened and the upper regions of the atmosphere were reached, the surface would cool and become viscous, the bomb would assume its final form, whilst any movement of the still liquid interior would leave ridges on the surface of the various types described above. The characteristic pittings may possibly have been formed at this stage by gas bubbles coming to the surface, the thin covering over them being subsequently removed by cracking off in cooling. Finally, on approaching the highest point of its flight the bomb would become solid throughout and the process of surface cracking would begin. In falling on the soft sand, where they mostly have been found in this state, no injury would be inflicted on them. If they struck any hard object they would either be chipped or broken into fragments, such as have often been found. They would then lie on the surface and be subject to the abrading action of the sand, or be covered up and the original brilliancy of their surface be preserved until they were found.

PART III.

SUPPLEMENT TO THE CENSUS OF MINERALS OF WESTERN AUSTRALIA.*

In Bulletin 4 of this Department the author first published a census of the minerals of the State. Since then, several new minerals have been recognised, and a number of additional localities noted, all of which appear in the following list. The commoner rock-forming minerals, such as quartz, felspar, micas, amphibole, etc., have been omitted as before, except where their occurrence is of marked interest either for economic or scientific reasons.

Most of the localities mentioned are to be found on the 45-mile map of the State published by the Lands Department in 1900. In order that they may be more readily identified, the goldfield or division of the State in which they are situated, is always indicated, the following abbreviations being employed:—

K.—Kimberley G.F.
Pil.—Pilbarra G.F.
W.P.—West Pilbarra G.F.
Ash.—Asburton G.F.
Gas.—Gascoyne G.F.
P.H.—Peak Hill G.F.
M.—Murchison G.F
Yal.—Yalgoo G.F.
E.M.—East Murchison G.F.
M.M.—Mt. Margaret G.F.
N.C.—North Coolgardie G.F.
Ygn.—Yilgarn G.F.
C.—Coolgardie G.F.
B.A.—Broad Arrow G.F.
E.C.—East Coolgardie G.F.
N.E.C.—North-East Coolgardie G.F.
Dun.—Dundas G.F.
P.R.—Phillips River G.F.
Dk.—Donnybrook G.F.

Localities Outside Goldfields.

N.E.—North of 27° South and East of 121° East.
N.W.—North of 27° South and West of 121° East.
S.W.—South of 27° South and West of 121° East.
S.E.—South of 27° South and East of 121° East.

Alunogen (*Hydrous sulphate of aluminium*).—Parker's Range, Ygn.

Asbolite (*Hydrated oxide of manganese and cobalt*).—Kalgoorlie, E.C.; Kurnalpi, N.E.C.

Azurite (*Hydrated carbonate of copper*).—Croydon, W.P. Rothsay, Yal.; Narra Tarra, S.W.; Murrin Murrin, M.M.; Broad Arrow, B.A.

Bauxite (*Hydrated oxide of aluminium*).—Wongan Hills, S.W.; Mahogany Creek, S.W.; Smith's Mill, S.W.; Mt. Baker, S.W.; Menzies, N.C.; Bardoc, B.A.

Bismuth (*Native metal*).—Yalgoo, Yal.

Bismutite (*Hydrated carbonate of bismuth*).—Yalgoo, Yal.

Bitumen (*Oxygenated mixture of hydro-carbons*).—Wilgi Mia, Weld Ranges, M.

Blende (*Sulphide of zinc*).—Croydon, W.P.; Kalgoorlie, E.C.; Norseman, Dun.

Bornite (*Sulphide of copper and iron*).—Uaroo, N.W.

* Bulletin No. 4. The Mineral Wealth of Western Australia. Chap. xii. Census of minerals of Western Australia. Perth: By Authority, 1900.

Calcite (*Carbonate of calcium*).—

(1.) Limestone.—Napier Range, N.W.; Oscar Range, N.W.; Geikie Range, N.W.; Hull Range, N.W.; Fossil Hill, N.W.; Mt. Pierre, N.W.; Range South of Mt. Pierre, N.W.; Mt. Bertram, K.; Mt. Dockrell, K.; Eliot Range, K.; Albert Edward Range; Ord River, K.; Mt. Panton and all along West side of Great Antrim Plateau, K.; Minilya River, N.W.; Gascoyne River, N.W.; Barrow Island and other islands off the North-West coast; Sharks Bay, Geraldton, Fremantle, Margaret River, and elsewhere along the West coast; Gingin, Yatheroo, and Dandarragan, S.W.; Israelite Bay, Eyre, Eucla, and elsewhere along the South coast between those points extending inland over 150 miles; etc.

(2.) Crystallised Secondary Calcite.—Brockman's, K.; Mt. Magnet, M.; Kanowna, N.E.C.; Broad Arrow, B.A.; Coolgardie, C.; Red Hill, C.; Yalingup, and elsewhere in the Margaret River Cave District; etc.

Cassiterite (*Oxide of tin*).—Cogelgong Creek, Pil.; Shaw Tinfields (near Eley's Well), Pil.

Cerussite (*Carbonate of lead*).—Uaroo, N.W.; Narra Tarra, S.W.

Cervantite (*Oxide of antimony*).—Wiluna, E.M.

Chalcocite (*Sulphide of copper*).—Uaroo, N.W.; Rothsay, Yal.; Murrin Murrin, M.M.; Geraldine, S.W.; Arrino, S.W.; Ravensthorpe, S.W.

Chalcopyrite (*Sulphide of copper and iron*).—Uaroo, N.W.; Rothsay, Yal.; Yalgoo, Yal.; Serpentine, S.W.; Kalgoorlie, E.C.; Ravensthorpe, P.R.

Chrysocolla (*Hydrated silicate of copper*).—Croydon, W.P.

Coal (*Hydrous bituminous coal*).—

(1.) Upper Irwin River, S.W.; Dongara S.W.; Collie, S.W.; Dardanup, S.W.; Fly Brook, S.W.

(2.) Brown Coal.—Coolgardie, C.; Fitzgerald River, S.W.

Coolgardite (*Telluride of gold, silver, and mercury*).—Kalgoorlie, E.C.

Copper (*Native metal*).—Roebourne, W.P.; Uaroo, N.W.; Rothsay, Yal.

Cuprite (*Oxide of copper*).—Uaroo, N.W.; Day Dawn, M.; Murrin Murrin, M.M.; Wongan Hills, S.W.; Ravensthorpe, P.R.

Dolomite (*Carbonate of calcium and magnesium*).—

(1.) Dolomite rock.—Braeside, Pil.; Goddard's Creek, N.E.C.

(2.) Crystallised Secondary Dolomite.—Goongarrie, N.C.; Bardoc, B.A.; Kalgoorlie, E.C.

Elaterite (*Oxygenated hydro-carbon*).—Cranbrook, S.W.

Electrum (*Alloy of gold and silver*).—Donnybrook, S.W.

Emmonsite (*Hydrated tellurite of iron*).—Kalgoorlie, E.C.

Enargite (*Sulpharsenate of Copper*).—Kalgoorlie, E.C.

Epidote (*Silicate of calcium, aluminium, and iron*).—Kalgoorlie, E.C.; Mundaring, S.W.

Fluorite (*Fluoride of calcium*).—Kalgoorlie, E.C.

Fuchsite (*Silicate of aluminium, chromium, and potassium*).—Roebourne, W.P.; Kalgoorlie, E.C.

Gadolinite (*Silicate of iron, beryllium, and yttrium*).—Cogelgong Creek, Pil.

Galena (*Sulphide of lead*).—Uaroo, N.W.; Yannerie River, N.W.; Norseman, Dun.

Garnet (*Almandine, Silicate of iron and aluminium*).—Parker's Range, Ygn.; Ravensthorpe, P.R.

Gold (*Native Metal*) :—

Pilbarra G.F.—Lalla Rookh, Boodalyerrie Creek, North Pole, North Shaw, Western Shaw, Middle Creek, Salgash, Just-in-time.

West Pilbarra G.F.—Station Peak.

Ashburton G.F.—Tooree, McKenzies.

Peak Hill G.F.—Ravelstone, Wilgeena.

East Murchison G.F.—Kingston, Mt. Pascoe, Mt. Clifford, Mt. Zephyr, Gum Creek.

Mt. Margaret G.F.—Monowai, Erlistoun, Mt. Clarke (Ogilvie's), Cork Tree, British Admiral, Laverton, Mt. Barnicoat, Merolia, Jubilee, Childe Harold, Korong, Redcastle, Murrin Murrin, Malcolm Creek, Dodger's, Middlesex, Doyle's Find.

Yalgoo G.F.—Nynghan, Naiaunda, Field's Find, Cagacarron.

North Coolgardie G.F. — Mt. Wilga, Yundamindera (Granites), Quondong, La Tosca, Kookynie, Woolgar, Isabel, Riverina, Mulwarrie, Davyston, Comet Vale, Pingin.

Yilgarn G.F. — Duladgin Mt. Caudan, Blackbourne, Mt. Rankin, Greenmount.

East Coolgardie G.F.—Waterfall.

North-East Coolgardie G.F.—Black Hill, Sudden Jerk, Mulgabbie, Jubilee, Gordon, Camelia.

Phillips River G.F.—Ravensthorpe, Harbour View.

Donnybrook G.F.—Donnybrook.

Localities outside proclaimed Goldfields.—Preston River, S.W.

Gold amalgam (*Alloy of gold and mercury* .—Kalgoorlie E.C.

Goldschmidtite (*Telluride of gold and silver*).—Kalgoorlie E.C.

Graphite (*Carbon*).—Mounts Brook, S.W.; Oldfield River, S.W.; Bulong, N.E.C.

Gypsum (*Hydrous sulphate of calcium*).—Boulder, E.C.

Hæmatite (*Oxide of iron*).—Horseshoe, P.H.; Mt. Beasley, P.H.; Blackboy Hill, S.W.; Bridgetown, S.W.; Parker's Range, Ygn.; Kalgoorlie, E.C.

Halloysite (*Hydrated silicate of aluminium*).—Norseman, Dun.

Hypersthene (*Silicate of iron and magnesium*).—Northam, S.W.

Kalgoorlite (*Telluride of gold, silver, and mercury*).—Kalgoorlie, E.C.

Lepidolite (*Fluosilicate of aluminium, potassium, and lithium*).—Cocanarup, P. R.; Ravensthorpe, P. R.

Limonite (*Hydrated oxide of iron*).—

Some more important localities are:—Whim Creek, W.P.; Wongan Hills, S.W.; Mt. Baker, S.W.; Mahogany Creek, S.W.; Greenbushes, S.W.; Herdsman's Lake, S.W.; Mt. Jackson, Ygn.; Parker's Range, Ygn; Murrin Murrin, M.M.; Menzies, N.C.; Vosperton, N.E.C.; Mulgarrie, N.E.C., etc.

Löllingite (*Arsenide of iron*).—Kalgoorlie, E.C.

Magnesite (*Carbonate of magnesium*).—Kalgoorlie, E.C.

Magnetite (*Oxide of iron*).—Ravensthorpe, S.W.

Malachite (*Hydrated carbonate of copper*).—South of Mt. Dockerell, K.; Mons Cupri, W.P.; Croydon, W.P.; Maitland River, W.P.; Upper Nickol, W.P.; Red Hill, Ash.; Uaroo, Ash.; Day Dawn, M.; Gabanitha, M.; Yandanooka, S.W.; Murrin Murrin, M.M.; Kalgoorlie, E.C.; Ravensthorpe, P.R.; Harbour View, P.R.

Molybdite (*Oxide of molybdenum*).—Clackline, S.W.

Muscovite (*Silicate of aluminium and potash*).—Greenbushes, S.W.

Opal (*Hydrated silica*).—

(1.) Common opal.—Yarra Yarra, N.W.; Yundamindera, N.C.; Burbanks, C.

Orthoclase (*Silicate of aluminium and potassium*).—In large crystals at Parker's Range, Ygn.; Ravensthorpe, P.R.

Petzite (*Telleride of gold and silver*).—Kalgoorlie, E.C.

Psilomelane (*Hydrated oxide of manganese*).—Coolgardie, C.; Murrin Murrin, M.M.

Pyrrhotite (*Sulphide of iron*).—Norseman, Dun.; Parker's Range, Ygn.

Quartz (*Silica*).—

(1.) Ordinary quartz.—Occurs in every district as a constituent of rocks or veins. Good crystals occur at Kalgoorlie, E.C.; York, S.W.

(2.) Chalcedony.—Widely distributed amongst the older rocks in the form of jasper "bars," as at the Marble Bar, etc. Also occurs at Paddington, B.A.; Siberia, C.

Roscoelite (*Silicate of aluminium, vanadium, etc.*).—Kalgoorlie, E.C.

Rutile (*Oxide of titanium.*)—Kalgoorlie, E.C.; Greenbushes, S.W.

Siderite (*Carbonate of iron*).—Kalgoorlie, E.C.

Spodumene (*Silicate of aluminium and lithium*).—Ravensthorpe, S.W.

Stibiconite (*Hydrated oxide of antimony*).—Wiluna, E.M.

Stibnite (*Sulphate of antimony*).—Wiluna, E.M.

Sulphur (*Native element*).—Mt. Magnet, M.

Tantalite (*Tantalite of iron.*)—Greenbushes, S.W.

Tellurium (*Native element*).—Kalgoorlie, E.C.

Topaz (*Fluosilicate of aluminium*).—Londonderry, C.

Tourmaline (*Silicate of boron, aluminium, etc.*).—Cocanarup, P.R.; Ravensthorpe, P.R.

Vanadinite (*Chlorovanadate of lead.*)—Mulline, M.C.

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1903.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 7.

Notes on the Auriferous Reefs of Cue and Day Dawn,

BY

W. D. CAMPBELL,
ASSISTANT GEOLOGIST.

WITH A MAP.

Issued under the authority of the Hon. H. Gregory, M.L.A., Minister for Mines.

PERTH:
BY AUTHORITY: WM. ALFRED WATSON, GOVERNMENT PRINTER.
1903.

PREFACE.

THE following notes on the Auriferous Reefs of Cue and Day Dawn were prepared by Mr. W. D. Campbell, in connection with the question of boring for reefs in that district. The notes serve in some measure as an explanation of the map by which they are accompanied.

The map and accompanying notes were submitted to the Honourable the Minister for Mines, who ordered them to be printed for public information.

A. GIBB MAITLAND,
Government Geologist.

Geological Survey Office,
Perth, 6th March, 1903.

NOTES

ON THE

AURIFEROUS QUARTZ REEFS

OF

CUE AND DAY DAWN (MURCHISON GOLDFIELD).

The two mining centres of Cue and Day Dawn are contiguous, and the two towns are but three miles apart. Cue lies mostly within an area of granite, the boundary of which passes through the southern portion of the town; to the southward, including Day Dawn, is an area of hornblendic rocks, comprising diorite, quartz diorite, and amphibolites. Both the granite and amphibolites are traversed by quartz reefs in a remarkably diversified manner. In the centre of the town of Cue, on the diorite boundary, there is a prominent quartz reef, which forms a central point, from which radiate a number of lines of quartz veins northerly and southerly. Those to the northward, in the granite, are the most numerous, and these again are traversed by shorter east and west veins, and also by some that are very flat; these and the north and south veins have mostly a westerly underlie. The east and west veins in the granite mostly underlie to the north, while those in the amphibolites underlie to the south. These characteristics appear to indicate that the quartz veins fill cracks produced by an upward pressure exerted deep down below this centre; to the southward of Cue the quartz reefs trend chiefly to the south-west, with occasional short east and west veins; the former follow the general lines of structure and foliation of the amphibolites.

The quartz comprising the reefs frequently show variations from the truly intrusive type of solid quartz, with and without casing and walls, for it frequently has inclusions of the surrounding rock in a foliated condition, and there is often a confusedly crystalline intermixture of quartz and felspar or pegmatitic structure and a segregation and infiltration of the quartz. The quartz

varies from translucent to opaque white, and with bluish and greenish tints and occasionally ferruginous, the latter chiefly where the hornblendic rocks occur. The green colour appears mostly in the north and south veins, and is probably due to the formation of epidote, a mineral of secondary origin. The blue colour is mostly associated with the more solid reefs and veins.

The physical aspects about Cue comprise a flat granitic plain to the north, with several small isolated table-top hills of granite about one mile distant from the town, and a much larger mass three miles north-easterly. These rise abruptly with a steep slope from the plain, with a short perpendicular cliff skirting the top; they are evidently remnants of an old plain level ranging up to forty feet or more above the present one, these portions having resisted denudation that has carried away the surrounding rock. Some portions of the tops of these flat hills are protected by a foot or more of quartzite capping, consisting of a siliceous breccia. Beyond these hills the plain stretched northwards to the Weld range of mountains, about 40 miles distant, which appear above the horizon. To the westward the plain extends to Cuddingwarra, about 10 miles, while to the south is a line of diorite hills and extending both easterly and south-westerly, skirting the margin of the granite. These hills attain their highest elevation at Trenton Hill, one and a-half miles south-west off Day Dawn. The next highest is the principal hill near Cue, about three-quarters of a mile due east from the centre of the town. The water level is generally between 90 and 100 feet from the surface; it is occasionally brackish, but frequently potable.

QUARTZ REEFS IN THE GRANITE.

The Light of Asia, the easternmost of the radiating lines of reef appears in the granite at the northern foot of the diorite hill near the railway granite quarry, and passes through the Mystery G.M.L., No. 1296, which is a portion of what was formerly the Lady Hynes, and then through the extinct leases Recruit and New Warrior. It comprises two reefs about 100 feet apart and two feet in width, and almost perpendicular, which crop out conspicuously. These were opened out by some shafts and cuts in 1899 and 1900, but with only moderate results.

The next outcrop of the reef is in the Nil Desperandum, No. 1292, known first as the New Eldorado, and then as the Golden Crow's Nest. The underlie is 50° to west. The alluvial "Pearling Ground" is situated here. The extinct leases Vulcan, Star of Asia, and Murchison Monarch were also along this line of reef, which takes here a northerly course. In the last-mentioned lease a strong outcrop occurs, now included in the Machine Area No. 19; it then crosses the Gem of Cue Extended, No. 1020, where the western termination of the Agamemnon Reef occurs, and it passes into the Light of Asia South, No. 838, Light of Asia, No. 1148, and Queen of

the May Extended, No. 1252. The main shaft of the Light of Asia is on the underlay of 46° down to a vertical depth of 210 feet. The No. 1 level, at 90 feet v.d., has been driven on 200 feet both north and south, with a considerable amount of stoping; No. 2 level, at 140 feet v.d., has been driven 70 feet both north and south; No. 3 level, at 195 feet v.d., has been driven north 120 feet. The reef has a width of 10 feet, and the quartz throughout has mostly a brownish colour; it shows gold freely in places. In the Queen of the May Extended the main reef has been opened up by incline and vertical shafts to a depth of 100 feet, so also has a cross reef dipping north in the Queen of the May, No. 1151. The yield from these leases, according to the statistics of the Mines Department, is as follows:—

Light of Asia Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
1899 ...	Lady Hynes	1165	67	*53·2		
1900 ...	Do.	...	89	†61·07		
					156	114·27
1900 ...	Mystery (dollied specimens)	1296	...	...	...	(2·00)
1897 ...	New Eldorado ...	1045	25	5		
1898 ...	New Eldorado, afterwards Nil Desperandum, No. 1292, subsequently	...	39·5	‡194·87		
1902 ...	Perseverance	1329	24	29·9		
1899 ...	Golden Crow's Nest ...	1149	10	·88		
					98·5	230·65
1897 ...	Star of Asia	958	...	...	54	5
1900 ...	Light of Asia... ...	1148 (964)	1,247	1,052·25		
1901 ...	Do.	...	1,171	667·05		
1902 ...	Do.	...	1,129	695·83		
					3,547	2,415·13
1899 ...	Queen of the May ...	1151	208	169·98		
1900 ...	Do.	...	416	437·95		
1901 ...	Do.	...	847	758·05		
1902 ...	Do.	...	761·5	571·15	2,232·5	1,937·13
					6,088	**4,704·18**
					= A yield of 15·454dwts. per ton.	

* Includes 2·70 ozs. dollied specimens.
† ,, 18·20 ,, ,,
‡ ,, 18 ,, ,,

Approximately parallel to the Light of Asia reef, and about 44 chains easterly from the Nil Desperandum, is a very broken series of reefs having a north and south course commencing at the edge of

the diorite, and grouped as the Sarepta and Great White Eye Reefs. The underlie ranges up to 52° and is to the west; the thickness is mostly two feet.

At the Duke of York, Nos. 1275 and 1287, a grey-coloured porphyry dyke accompanies the reef, and it also occurs at another quartz outcrop a quarter of a mile east from here. A similar rock can be seen on both sides of the railway line near the explosives reserve at Day Dawn, about a quarter of a mile north-west from the Kinsella North, No. 292D.

The Winchester Reef intermediate between the Light of Asia and Great White Eye Reef; it traverses the extinct leases of Winchester and Micawber, originally the Wallace.

The Normanby Reef is nearly at right angles to the two last-mentioned reefs, extending south-westerly from the Duke of York and traversing the extinct lease New North Cue, No. 1255. At the Normanby, No. 1143, it has a north underlay of 70°, and is about two feet wide, and has been worked to 120 feet depth. The country rock is a hard gneissic granite, with intrusions of a porphyritic rock.

Sarepta Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
1901 ...	Sarepta	1272	...	...	**194·5**	**100·45**
					= a yield of 10·329dwts. per ton.	

Great White Eye Reef.

Previous to 1897	Great White Eye, subsequently Duke of York	882	190	115		
1897 ...	Do.	...	59	33·75		
1898 ...	Do.	...	241	94·85		
1899 ...	Do.	...	81·5	56·34		
1900 ...	Do.	...	17	13·25		
1901 ...	Duke of York ...	1275	111	111·45		
1902 ...	Do.	...	440	323·32		
					1,139·5	**747·96**
					= a yield of 13·128dwts. per ton.	

Winchester Reef.

		G.M.L.	Ore Crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Winchester	1009	49	56·5		
1897 ...	Do.	...	104	76·5		
1898 ...	Do.	...	17	11·5		
					170	144·5
Previous to 1897	Wallace	999	18	14		
1898 ...	Do.	...	16	8·15		
					34	22·15
					204	**166·65**
					= a yield of 16·338dwts. per ton.	

Normanby Reef.

Previous to 1897	Normanby ...	1143 (799)	295	269		
1897 ...	Do.	...	310	219		
1898 ...	Do.	...	40	42·20		
1899 ...	Do.	...	172	264·15		
1900 ...	Do.	...	146	131·09		
1901 ...	Do.	...	131	101·90		
1902 ...	Do.	...	78·5	114·60		
1901 ...	New North Cue ...	1255	77	44		
					1,249·5	**1,185·94**
					= a yield of 18·984dwts. per ton.	

The Cue Victory Reef commences about ten chains easterly from the table-top hill near the Volunteer leases.

The Cue Victory lease, No. 1174, comprises the greater part of the extinct leases Commonwealth, No. 201, Golden Stream, and Golden Stream East. The western portion has a reef about 18 inches wide, with a north-easterly course, underlaying 30° to west; the eastern portion has an underlay of about 23° to north, and has been worked to a depth of 140 feet v.d., the width varying from a few inches to five feet. The main shaft is on the underlay 480 feet in length. There is a battery of 10 head of stamps here and four cyaniding vats of 40 tons capacity each. This line of reef extends through the Golden Stream Extended, No. 711, and the Golden Stream Extended North, No. 1245 (673), formerly the Republic.

Cue Victory Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Cue Victory	1174	448	650		
1897 ...	Do.	...	2,818	1,933·2		
1898 ...	Do.	...	3,057·5	1,450·79		
1899 ...	Do.	...	204·5	59·94		
1902 ...	Do.	...	18	12·10		
1902 ...	Cyaniding of 9,560 tons tailings	...	...	1,160·30		
					6,546	5,266·33
Previous to 1897	Golden Stream Extended	711	20	20		
1897 ...	Do.	...	30	69·33		
1898 ...	Do.	...	112	194·35		
1899 ...	Do.	...	135	201·10		
1900 ...	Do.	...	830	983·40		
1901 ...	Do.	...	1,215	982·05		
1902 ...	Do.	...	105	51·1		
					2,447	2,501·33
1899 ...	Republic, No. 673, subsequently Nil Desperandum, No. 1210, and Golden Stream Extended North, No. 1245	...	114	91·60		
1900 ...	Nil Desperandum ...	1210	115	25·99		
					229	117·59
					9,222	**7,885·25**
					= a yield of 17·10dwts. per ton.	

The Agamemnon Line of Reef commences about 20 chains north-easterly from the Golden Stream Extended North, and follows an easterly course, with an underlay to the north from 44° to 50°, extending through the Gem of Cue Extended, No. 1020 (formerly Stawell United), Gem of Cue, No. 523, and the extinct leases Eclipse, Eclipse Extended, Cue Eclipse, Pacific, and Tasmania. The latter is now mostly comprised in the Agamemnon leases, Nos. 1310 and 1047, where it has been worked to a depth of 180 feet. The main shaft is vertical, 170 feet deep, cutting the reef at 124 feet, where the underlay is 30°. At the 100 feet level a length of 530 feet of driving has been done, and at the 160 feet level there are 300 feet of driving. There is a battery of 15 head of stamps here, and four cyaniding vats of 40 tons each. The line of reef extends about half a mile easterly from here on to the granite plateau.

Agamemnon Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Gem of Cue, Ltd.	523, 1020, 1044, 1127, 1152	90	84		
1897* ...	Do.	,,	96	73·3		
1898* ...	Do.	,,	862	593·35		
1899* ...	Do.	,,	4,826	3,286·6		
1900* ...	Do.	,,	5,850	3,550·45		
1902 ...	Do.	,,	18	5·80		
	Cyaniding of 11,960 tons tailings	,,	...	2,188·85		
	Extras	,,	...	102·4	11,742	9,884·75
1900 ...	New Eclipse	1243 (248)	30	22·50		
1901 ...	Do.	,,	21	7·15		
1901 ...	subsequently Ophir	1278 (248)	31	11·30	82	40·95
Previous to 1897	Eclipse	248, 663	72	32		
1898 ...	Do.	,,	206	97·66		
1899 ...	Do.	,,	210	132·35		
1900 ...	Do.	,,	142	72·30	630	334·31
Previous to 1897	Tasmania	483	...	...	55	24
Previous to 1897	Agamemnon ...	483 1046/7	50	51		
1897 ...	Do.	,,	976	588		
1898 ...	Do.	,,	3,324	2,178·56		
1899 ...	Do.	,,	1,955	1,208·96		
1900 ...	Do.	1047	134	73·30		
1901 ...	Do.	,,	823	525·65		
1902 ...	Do.	,,	1,044·33	867·5	8,306·33	5,492·97
					20,815·33	**15,776·98**
					=a yield of 15·158dwts. per ton.	

* Years 1897 to 1900 include South Volunteer, No. 1044, and North Volunteer Extended, No. 1127.

The next Group of Reefs is very broken. Commencing near the back of the Cue post office, the reef passes into the Caledonian Hill, No. 1068, where there are two parallel reefs underlaying west.

The main shaft here is being used as a water shaft. To the northward the line of reef is interrupted by a series of east and west reefs passing through the West Australian, No. 1172, where it underlays north, and then the Princess, No. 1150 (formerly Princess Ada No. 692), where it underlays south 30°. In the latter lease the old main shaft, 150 feet v.d., ends in an underlay, and from that depth stoping has been done to the surface, and some rich patches of gold were obtained. The reef is about two feet six inches wide, but variable.

A new main shaft is now being sunk to reach the reef further on the underlay. To the north of the Princess the north and south reef reappears in the Twilight South, No. 1090, Twilight, No. 774, and the South Volunteer, No. 1044, and another in the New Volunteer, No. 1135. These are very flat-lying—12° to 17° to west. The outcrop occurs on the eastern margin of the lease, and is composed of two quartz veins, about 18 inches thick; at 90 feet depth these are four feet apart. The quartz is white and cavernous, and shows gold freely in places. The material between is slightly ferruginous kaolin, probably a decomposed vein of amphibolite schist, which is being broken out by means of auger holes. In the Volunteer South Extended, No. 1145, what may be the same reef is being worked at a depth of from 95 to 110 feet; it is here a single quartz vein, and the granite is but slightly decomposed. A roll in the reef occurs in the middle of the lease, so that in the eastern portion it underlays to the east.

Further to the north, on the table-top hill, a north and south and an east and west reef occur, which have been worked by vertical shafts and open cut, and some rich gold patches were found; the ground was held at the time as the Mount Murchison and Emanuel leases.

There are some other flat-lying reefs in the New Volunteer Extended, No. 1259, previously the Conscript and Golden Garter, which pass into the western side of the table-top hill and into the Countess Extended, No. 1230, with a bearing towards the Salisbury Reef, three-quarters of a mile to the northward.

Group of Reefs from Cue Northwards.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Caledonian Hill	1068, (1100/1)	sluicing	...	...	40
1898 ...	Do.	...	5	9·25		
1899 ...	Do.	...	42	40·6		
1900 ...	Do.	...	18	6		
1901 ...	Do.	...	35	15·65		
					100	71·50
1897 ...	Princess Ada South ... subsequently	1059	64	9·55		
1901 ...	West Australian ...	1172	100	10·40		
					164	19·95
1899 ...	Princess Leases ...	(692), 1150, 1178	446	456·1		
1900 ...	Do.	...	490	576·45		
1901 ...	Do.	...	306	205·3		
1902 ...	Do.	...	10	4·65		
					1,252	1,242·50

GROUP OF REEFS FROM CUE NORTHWARDS—*continued.*

Year	Name	G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
1900 ...	Comforter	1234	29	13·15		
1902 ...	Do.	...	64	32		
					93	45·15
Previous to 1897	Twilight	774	110	138		
1897 ...	Do.	...	138	191·84		
1898 ...	Do.	...	227	287·10		
1899 ...	Do.	...	423	469·85		
1900 ...	Do.	...	388	324·75		
1901 ...	Do.	...	342	220·20		
1902 ...	Do.	...	45	17·5		
					1,673	1,649·24
1902 ...	Starlight	1325	...	...	105	90·05
Previous to 1897	South Volunteer ...	1044	50	30		
(Subsequent returns to 1900 are included in Gem of Cue.)						
1901 ...	South Volunteer ...	1044	61	37		
1902 ...	Do.	...	415	217·5		
					526	284·5
Previous to 1897	Volunteer	1070	108	158		
1897 ...	Do.	...	54	36		
1898 ...	Do.	...	37·5	40·6		
					199·5	234·60
1899 ...	Volunteer South Extended	1145, 1214, 1231	430	333·4		
1900 ...	Do.	...	1,105	979·83		
1901 ...	Do.	...	1,465	1,660·60		
1902 ...	Do.	...	3,135	2,328·00		
					6,135	5,301·83
1898 ...	New Volunteer ...	1135 (1070)	463	210·39		
1899 ...	Do.	...	302	293·89		
1900 ...	Do.	...	474	527·27		
1901 ...	Do.	...	698	855·55		
1902 ...	Do.	...	1,434	1,383·00		
					3,371	3,270·10
Previous to 1897	Conscript ... ... subsequently	1061	12	11		
1897 ...	Golden Garter ...	1111	72	48·88		
1898 ...	Do.	...	412	182·52		
1899 ...	Do.	...	136	10		
					632	252·40
1899 ...	Struggle	1153	35	6·64		
1890 ...	Do.	...	90	27·80		
					125	34·44
1899 ...	New Venture	...	...	...	24	5·30
1902 ...	Volunteer Deeps ...	1383	...	...	10	4·65
					14,409·5	**12,506·21**
					= a yield of 17·358dwts. per ton.	

The CUE ONE REEF in Cue No. 1 Gold Mining Lease, No. 203, Rising Sun, No. 1248, and Rising Sun North, No. 1262 has a north and south course, and it appears to be traceable, southerly, to within the municipal boundary, in a line with the quartz reef in the centre of the town. In the Cue No. 1 it has an underlay of 44°, with a width of two to three feet. The quartz has mostly a brown colour down to the 250 feet level; below this it has a green and blue tint. The new main shaft is vertical, 300 feet in depth. At the 200 feet level the driving extends southerly 470 feet, or nearly to Livingstone Street, and at the 295 feet level the drives extend 250 feet. The reef is well defined at these levels, and shows gold freely in places. The ore is said to have been also good near the surface. At the intermediate levels it was of moderate grade only. The re-making of the richer stone has had an encouraging effect upon the mining in the district. There is a battery of 20 head of stamps here, which makes crushings for the public, and eight cyaniding vats of 40 tons capacity each. In the Rising Sun the same reef evidently occurs, besides two other minor lodes; the workings extend to 280 feet depth. The country rock is a gneissic granite.

The LADY MARY REEF is seven chains to the westward of, and nearly parallel to the Cue One, and underlying 39° to west. The reef comprises a double lode, having a total width of 10 feet, and has been worked with an underlay shaft to a depth of 135 feet. It traverses the Cue One South, No. 1274, Lady Florence, No. 1265, previously Lady Mary, and Rising Sun West, No. 1276. The machinery is now dismantled.

A reef which outcrops at the small table-top hill near the south-east corner of the racecourse reserve may be a re-appearance of either the Cue One or the Lady Mary reef.

LADY MARY AND CUE NO. 1 REEFS.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	oz.	tons.	oz.
Previous to 1897	Lady Mary South	No. 1 157	147	263·8		
1897 ...	Do.	...	121	216		
1898 ...	Do.	...	30	54·6		
1899 ...	Do.	...	121	355·05		
1900 ...	Do.	...	16·5	17·55		
					435·5	907

LADY MARY AND CUE No. 1 REEFS—*continued.*

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Cue Consolidated includes both Lady Mary and Cue No. 1 reefs	...	6,856	7,193·5		
1897 ...	Do.	60, 170, 203, 674, 1140, 1692, 964, 1002, 1128, 1130	9,484	6,729·6		
1898 ...	Do.	...	6,652	4,550·27		
1899 ...	Do.	...	650	1,158·6		
	Extras ...	...	...	23·49		
	Plates ...	...	...	370·66		
1900 ...	Do.	...	434·5	526·46		
	and to Lady Mary ...	1222 (674)	38	21·62		
1901 ...	Cue No. 1	203	283	130·05		
1902 ...	Do.	...	4,203	3,824·10		
	Cyaniding of 9,200 tons tailings	...	...	1,363·40		
					28,600·5	25,891·76
1900 ...	Rising Sun	1248 (60)	80	44·85		
1901 ...	Do.	...	871	701·90		
1902 ...	Do.	...	247	143·70		
					1,198	890·45
1901 ...	Rising Sun North ...	1262	...	...	56	39·90
					30,290	**27,729·11**
					= a yield of 18·309dwts. per ton.	

The COUNTESS REEF on the north side of the table-top hill strikes in a north-westerly direction from the Golden Stream Extended, and has a southerly underlay; a considerable amount of work has been done on it down to water level. The new main shaft in the Countess, No. 1212, has been sunk to a depth of 335 feet in a hard hornblendic granite, but without meeting with the reef; and a crosscut was commenced to endeavour to intersect it. The outcrop of this reef extends through the New Arcadia, No. 1311, which was previously the Arcadia, No. 811, and Arcadia Extended, No. 640, and also through Countess North, No. 1269, formerly Arcadia North, and including portions of the extinct Ashbourne and Once Again Extended.

The SALISBURY REEF, three-quarters of a mile further to the north, may be a continuation of the Countess Reef. A line of extinct leases extend between them—the Lady Bess, Inazella, and the South Salisbury, No. 1289 (which includes the extinct Lady Catherine lease).

The underlay is here 65° to west. In the workings in the Salisbury, No. 1046, the underlay is 74° down to the 100 feet level, and thence 53°. The main shaft is vertical 215 feet, cutting the reef at 190 feet. The width of reef varies from two to six feet, and is of a brownish colour; it carries a considerable quantity of iron pyrites. A second reef occurs parallel to this one, on the western side of the lease, but it has not been worked.

Countess Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
1898 ...	Countess	1066	157·5	217·22		
1899 ...	Do.	...	250·5	169·70		
1900 ...	Do.	...	10	8·5		
1901 ...	Countess G.M. Company (No-Liability)	1212	61	54·45		
1902 ...	Do.	...	54	13·75		
					533	463·62
Previous to 1897	Arcadia	640, 811	565	739		
1897 ...	Do.	...	691	438·10		
1898 ...	Do.	...	351·5	302·71		
1899 ...	Do.	...	601	271·76		
1900 ...	Do.	...	65	34·70		
1901 ...	Do.	...	122	50·35		
1902 ...	New Arcadia	1311	197	74·05		
					2,592·5	1,910·67
Previous to 1897	Ashbourne	750	501	499		
1897 ...	Do. ... ... subsequently	...	168	57·67		
1900 ...	Arcadia North ...	1179	6	1·25		
1901 ...	Do.	...	17·5	2·5		
					692·5	560·42
1902 ...	Countess Extended ...	1230	...	...	49	19·70
					3,867	**2,954·41**
					= a yield of 15·280dwts. per ton.	

Salisbury Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
Previous to 1897	Salisbury	1046	138	175		
1897 ...	Do.	...	459·5	872·72		
1900 ...	Do.	...	172	95·15		
1901 ...	Do.	...	290	90·15		
1902 ...	Do.	...	1,403	1,018·68		
					2,462·5	**2,251·70**
					= a yield of 18·288dwts. per ton.	

The Young Colonial and the Welcome Reefs radiate north-westerly from the central quartz reef in Cue, and underlay to the west about 65°. The former passes under the Warden's residence, and after an interval reappears in the Young Colonial, No. 1297 (1124), which was for a time called Maud, and at the south-west corner of the racecourse reserve. The Welcome reef traverses the margin of the extinct leases Maori Chief, Cue, New England (previously Maori), Cue North, Welcome, and Cue Extended leases, and is, in places, five feet wide.

The Bonnie Dundee and Campania Reefs also radiate from the same centre, and underlay to the west about 65°, the widths range from 1ft. 6in. to three feet. The latter reef passes through the extinct leases Golden Dundee, Real McKay, and Campania. It then traverses the Campania No. 1 North and the extinct leases Warnambool and Anglo-Saxon. The Campania has also a transverse reef of greenish quartz; an amphibolite schist vein accompanies the main reef here and in the Anglo-Saxon.

Young Colonial Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
1898 ...	Young Colonial ...	1124	154·50	264·37		
	subsequently					
1899 ...	Maud	1144	75	109·63		
1900 ...	Do.	...	77	70·09		
	subsequently					
1902 ...	Young Colonial ...	1297	43	20·6		
					349·5	**464·69**
					= a yield of 1oz. 6·590dwts. per ton.	

Welcome Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
1897 ...	New England... ...	1107	7	9		
	subsequently					
1899 ...	Maori	1157 (1121)	18	5·5		
1900 ...	Do.	...	20	7·85		
					45	**22·35**
					= a yield of 9·933dwts. per ton.	
Previous to 1897	Maori Chief	537	unknown tons.	59	unknown tons.	59

Campania Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
1901 ...	Real Mackay	1266	40	15·25	**40**	**15·25**
					= a yield of 7·625dwts. per ton.	

The Belgravia, Deceiver, and Victoria Reefs lie to the westward of the town and are approximately north and south reefs, and have a westerly underlay. The quartz forming the reefs has mostly a greenish tint. The Deceiver has had the most work done on it, and the mine has been resuscitated and a new main shaft is being sunk.

The Victoria Reef extends northerly from the diorite boundary, and has a width of 1ft. 6in. to three feet, with a considerable intermixture of green-coloured quartz.

The Buttercup Reef lies $1\frac{1}{2}$ miles north-west from the Victoria reef.

At Tailings Area No. 12, on the east side of the Belgravia Lease, there are four cyaniding vats with a capacity of 40 tons each.

Belgravia Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Belgravia Leases ...	1056/7	102	77		
1897 ...	Belgravia Central ...	789	90	70·46		
1898 ...	Do.	...	73·5	43·2		
1899 ...	Do.	...	16	118·4		
1902 ...	Research	1333	24	16·35		
					305·5	**325·41**
					= a yield of 1oz. 1·302dwts. per ton.	
1902 ...	Cue Gold Recovery Co., cyaniding 480 tons tailings	T.A. 12	...	60·05		
1902 ...	Chesson and Heydon, cyaniding 480 tons tailings	T.A. 12	...	76·50		
1902 ...	Cue Public Battery, 10 head of stamps, cyaniding 1,000 tons tailings	M.A. 5	...	114·65		
					...	**251·20**

Deceiver Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
Previous to 1897	Lily No. 2 South ...	697	25	22		
1897	Do.	...	10	4		
	Deceiver	(697) 1115	31	52·76		
1898 ...	Do.	"	374	801·72		
1899 ...	Do.	"	159	350·3		
1900 ...	Do.	"	172	260·5		
1901 ...	Do.	"	94	122·98		
1902 ...	Brilliant G.M. (Cue)	...	55	24·15		
					920	1,638·41

DECEIVER REEF—*continued.*

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
1897 ...	Two Lilies	1113	55	72·38		
1898 ...	Do.	...	35	20·85		
1900 ...	Deceiver North ...	1213	44	76·7		
1901 ...	Do.	...	124	295·45		
					258	465·38
Previous to 1897	Lily	701	480	800		
1897 ...	Do.	...	128	147·25		
1898 ...	Do.	...	15	12·35		
					623	959·6
Previous to 1897	Lily North	1049	14	83		
1897 ...	Do.	...	56	127		
					70	210
1898 ...	Lily North Extended	1131 (1049)	...	...	75	143·05
					2,251	**3,878·40**
					= a yield of 1oz. 14·459dwts. per ton.	

VICTORIA REEF.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
Previous to 1897	Victoria	1118 unknown location.	...	...	...	277
1897 ...	Do.	...	11	23·95		
1898 ...	Do.	...	52·5	57·45	74·5	88·65
1900 ...	Do.	1,177 (1,118)	11	7·25		
Previous to 1897	North Victoria ...	817	...	...	203	313
					277·5	**401·65**
					= a yield of 1oz. 8·946dwts. per ton.	

BUTTERCUP REEF.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
1897 ...	Buttercup	1109	...	...	**100**	**64**
					= a yield of 12·80dwts. per ton.	

The MYSTERY REEF, in the extinct lease No. 534, is nearly one mile due north from the Victoria reef, and 30 chains north-westerly from the north end of the Campania reef. It has a north and south course, underlaying 40° west; it is about two feet in width. There are three shafts and some workings on the outcrop. The Strathfield reef occurs 50 chains further west.

The Red White and Blue Reef is situated about one mile to the north of the hill in the racecourse reserve; it has a south-westerly course, with an underlay of 50° to the north-west, and a width of two to four feet. The country rock is gneissic; a vein of hornblende schist accompanies the reef.

At the south end of this reef the Golden Leaf Reef crosses it in a north-west direction.

The Kangaroo Reef occurs about 30 chains to the westward, and for half a mile north-easterly it occupies a slight ridge in the prevailing flat surface of the ground.

The reef varies from a few inches to five feet, and has a westerly underlay of about 48°. It traverses the extinct lease George Higinbotham, and some of the small quartz veins here have quite a fibrous structure at right angles to the sides, with green-coloured inclusions.

The reef then passes into the Leviathan, No. 183, there is here an underlay shaft of 200 feet vertical depth; the reef outcrops strongly, with a width of about four feet, and in the adjacent lease, the Kangaroo, No. 1306 (672), the thickness is about two feet.

Sundry Reefs, Eastward of the Kangaroo reef are the extinct leases Highland Mary, No. 718, and Gem, No. 538; the reef in the latter may be a continuation of the Golden Leaf. It then passes into the Argus, which had been previously known as the New Gem of Murchison, Independent, and Golden Gem, and in part as M.A. No. 18; it crosses here the south end of the Kangaroo reef with an underlay of 48° to the north-east. Midway between the Kangaroo and Campania reefs, and probably on the same line of fracture, is the Battlers' Hope Reef.

The Lombardy Reef is parallel to the Kangaroo, and lies about half a mile to the west, while three-quarters of a mile further west is the Jubilee, with a north-west course. About 20 chains to the eastward of the north end of the Kangaroo reef are the extinct leases Two Nations and Lady Godiva, previously City of St. Petersburg.

The Mafeking Reef is 25 chains farther north from the Kangaroo; it traverses the leases Hard Luck, No. 1159, and Mafeking, No. 1175. It has a north-west underlie and a width of two and a-half feet. A new main shaft is being sunk to intersect it more to the westward of the old workings. About 20 chains further along the line of the Mafeking reef, northerly, is the Union Jack Reef, adjacent to the north end of which is Garden Area No. 14.

To the north of the Union Jack, about 13 chains, is the Retreat Reef; the lease (No. 1338) was at one time known as the Duke of York, No. 1022. About 40 chains westerly from here is the Stanmore Reef with a south-west course.

Red, White, and Blue Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Red, White, and Blue	745/6 1119 1121	100	97		
1897 ...	Do.	...	241	102		
1898 ...	Do.	...	737	330·3		
1899 ...	Do.	...	25	7·75		
					1,103	537·05
					= a yield of 9·738dwts. per ton.	

Kangaroo Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
900 ...	Golden Gem	1220	...	...	10	5·2
898 ...	Geo. Higinbotham ...	178	46·5	13·25		
899 ...	Do.	...	104	34		
900 ..	Do.	...	27·5	41·35		
					178	88·6
897 ...	Leviathan	183	130	117		
898 ...	Do.	...	246	191·97		
899 ...	Do.	...	237	203·48		
900 ...	Do.	...	330	288·98		
901 ...	Do.	...	43	29·85		
902 ...	Do.	...	162·5	105·25		
					1,148·5	936·53
397 ...	Kangaroo	672	253	158·75		
398 ...	Do.	...	56	34		
399 ..	Do.	...	9	3·03		
902 ...	Do.	1306	160	101·38		
					478	297·1
					1,814·5	1,327·49
					= a yield of 14·632dwts. per ton.	

Sundry Reefs.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
revious to 1897	Golden Leaf	889	...	...	33	47
97 ...	Highland Mary ...	718	...	...	68	8
97 ...	Gem (Gem of Murchison G.M., Ltd.) subsequently	538, 993, M.A. 18	60	39		
00 ...	Gem	(538) 1216	32	16		
ay, 1902	New Gem of Murchison	1314	39	23·4		
ly, 1902	Gem of Murchison ...	1134	45	13·1		
ig.-Dec., 1902,	Argus	1328	142	111		
					318	302·5
91 ...	Battler's Hope, subsequently Carrington	1284	...	...	30	9·4
evious 1897	Two Nations	865	...	...	10	10
					459	376·9
					= a yield of 16·42dwts. per ton.	

Sundry Reefs—*continued.*

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom
			tons.	ozs.	tons.	ozs.
Previous to 1897	City of St. Petersburg	764	10	5		
	subsequently					
1897 ...	Lady Godiva	1116 (764)	30	25		
1898 ...	Do.	...	177	100·64	217	130·
					= a yield of 12·040dwts. per to	

Lombardy Reef.

1897 ...	Lombardy Leases ...	1034/5	210	138		
1898 ...	Do.	...	135	34·28		
1900 ...	Do.	...	Cyaniding	63	345	235·
					= a yield of 13·638dwts. per t	

Jubilee Reef.

1897 ...	Jubilee	1117	105	74·43		
1898 ...	Do.	...	744	269·55		
1900 ...	Do.	1168 (1117)	12·5	8·6	861·5	352·
					= a yield of 8·185dwts. per to	

Mafeking Reef.

1899 ...	Hard Luck	1159	50	32·45		
1900 ...	Do.	...	46	29·40	96	61
1900 ...	Mafeking	1175	58	61·40		
1901 ...	Do.	...	39	31·45		
1902 ...	Do.	...	71	22·05	168	114
					264	176
					= a yield of 13·39dwts. per to	

Union Jack Reef.

1897 ...	Union Jack	1037	55	18		
1901 ...	Do.	...	53	19·8	108	3
					= a yield of 7dwts. per ton.	

Retreat and Stanmore Reefs.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
revious to 1897	Duke of York ..	1022	30	30		
02 ...	Retreat ...	(1022) 1338	19·5	13·45		
					49·5	43·45
revious to 1897	Stanmore	887	...	...	63	66
					112·5	**109·45**
					= a yield of 19·458dwts. per ton.	

QUARTZ REEFS IN HORNBLENDIC ROCKS.

Taking now the reefs in the diorite and allied rocks, the easternmost in the area mapped is in the Fleur de Mai lease, one mile east of the rifle range. It has an east and west course, underlaying steeply to the north. The width is three feet, including some solid quartz on the hanging wall, and the remainder is ferruginous, friable quartz at 30 feet depth. The country rock shows only kaolinised material, with numerous branching stringers of quartz. On the boundary of one of the extinct leases here there is a cap of strongly magnetic ironstone conglomerate, which forms a low hill.

Fleur de Mai Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
vious to 1897	Le Premier Fleur de Mai	422	422	235		
8 ...	Do.	...	30	15·55		
					452	**250·55**
					= a yield of 11·086dwts. per ton.	

The Rose of England Reef is 15 chains south of the south end of the rifle range. It has a north-east course, underlaying 80° westerly. The main shaft is 160 feet v.d. in a fine-grained, foliated diorite, and passing into non-foliated rock at depth. The reef near the surface is about 18 inches wide. A good supply of potable water occurs in this shaft.

Rose of England Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefro
			tons.	ozs.	tons.	ozs.
Previous to 1897	Rose of England ...	662	300	42		
1897 ...	Rose	1110	21	12		
1901 ...	Rose of England ...	662	54	39·05		
					375	93·
					= a yield of 4,962dwts. per to	

The long extinct Lone Star Lease was, apparently, near here.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefror
			tons.	ozs.	tons.	ozs.
Previous to 1897	Lone Star	1076	...	...	17	7

From the central quartz reef, in the town, a reef extends half a mile southerly, with several large outcrops, as far as the Marvel Reef. The latter reef has a north-west course from there, underlaying 40° to east, with a width of about 18 inches. The country rock is a close-grained diorite.

Marvel Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrou
			tons.	ozs.	tons.	ozs.
1897 ...	Maybell, afterwards Consols	1108	15	5		
1897 ...	Marvel	599	50	20·35		
					65	25·
					= a yield of 7·80dwts. per ton	

The Catalpa Reef is the main southerly radiating reef. It outcrops in a remarkably prominent manner in the Catalpa, No. 1271 (1088), at one time known as Tellus, there being quite a wall of quartz 10 feet high and nearly eight chains long, with an underlay of 85° to west, and two to three feet thick. Galena occurs in the lode. The workings extend down to about water level. The Duchess, now surrendered, was situated on the northern end of the Catalpa. From the Catalpa the reef passes into the South Catalpa, No. 1282 (previously known as De Beers), where it diminishes in size. There is a second reef here, on the western side, which is very ferruginous; but little work has been done on this lease. Southward from here the main reef can be traced through the west end of the cemetery, and at intervals outcrops about eight chains eastward of the railway for a distance of about two miles, nearly to the Day Dawn railway station. It is mostly a white quartz, but bluish in places, and has a width of 18 inches to four feet, and is perpendicular.

Catalpa Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
01 ...	Duchess	1281	...	...	30	10·70
97 ...	Catalpa	1088	74	33	...	...
99 ...	Do.	...	134·5	47·68	...	...
01 ...	Do.	...	162	63·75	...	...
02 ...	Do.	...	529	199·65		
					899·5	344·08
99 ...	South Catalpa ...	1089	...	...	23	7·03
					952·5	**361·81**
					= a yield of 7·596dwts. per ton.	

The Princess Royal Reef outcrops strongly parallel to and 12 chains west of the main reef in the South Catalpa, and has an underlay of 47° northerly, and a width of two to five feet. At the south end it bifurcates. The main shaft is vertical to the first level, at 107 feet v.d., and then follows the underlay to the 180 feet v.d. level. The workings extend to the south boundary of lease No. 222; and a considerable amount of stoping has been done. There is a battery of 10 head of stamps here, and four cyaniding vats of 30 tons capacity each. The Royal Secret is on the south-east side of the main reef.

Princess Royal Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
evious to 1897	Princess Consolidated, Murchison	222, 653, 784	414	879		
97 ...	Do.	1016, 1048, 1114	3,132·5	2,764·89		
98 ...	Do.	...	2,349	1,680·71		
00 ...	Do.	...	33	39·30		
01 ...	Do.	...	348	497·40		
02 ...	Do. (cyaniding from 2,370 tons of tailings)	..	...	309·5		
					6,276·5	6,170·80
02 ...	Royal Secret	1295	449·5	364·00	449·5	364·00
					6,726·0	**6,534·80**
					= a yield of 19·431dwts. per ton.	

The LADY FORREST REEF is a quarter of a mile to the south-west, and is a cross reef to the last, with an underlay of about 45° to the south. It is a bifurcating reef of great width—the north reef ranging up to 12 feet, and the south reef to 18 feet wide. The main shaft is on the underlay, 130 feet v.d. A 20-head battery has lately been taken from here to the Murchison.

LADY FORREST REEF.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom
			tons.	ozs.	tons.	ozs.
1897 ...	Lady Forrest	335, 696, 1051	920	516		
1900 ...	Do.	...	57	63·15		
1901 ...	Do. now Cue Fingall No. 1217 (335)	...	137	115·10		
1902 ...	Do.	...	26	9·15		
					1,140	703·
					= a yield of 12·340dwts. per to	

The POLAR STAR and HOMEWARD BOUND REEFS are at the north end of the Rubicon line of reef, half a mile further westward, and striking diagonally across it, bearing about 63°. They are just within the amphibolite area, which extends southwards from here to below Day Dawn. In the neighbourhood of these reefs, and in the adjacent hill, a remarkably phonolitic form of this rock occurs. The main shaft of the Polar Star is 270 feet deep, and the lode has been driven on for 200 feet on either side of it, chiefly at the 80 feet level. There is a battery of 10 head of stamps here. At the Homeward Bound reef the amphibolite is slaty and foliated.

POLAR STAR REEF.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefron
			tons.	ozs.	tons.	ozs.
Previous to 1897	Polar Star	920	179	409·38		
1897 ...	Do.	...	339	545·70		
1898 ...	Do.	...	198	10		
1899 ...	Do.	...	108	34·60		
					824	999·68
					= a yield of 2·426dwts. per ton	

Homeward Bound Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Homeward Bound ...	398	39	75		
1897 ...	Do. ...	...	8·5	6		
1901 ...	Do. ...	...	16	13·75		
					63·5	94·75
					= a yield of 1oz. 9·842dwts. per ton.	

The Rubicon Line of Reef has mostly a north and south course for one mile, and is probably the northern continuation of the Great Fingall reef. It has a westerly underlie of 80°, and less. At the Crœsus No. 14D the workings have a depth of 100 feet; the country rock is a foliated amphibolite. A small copper lode occurs on the western side of the reef, trending south-easterly; and what may be portions of the same copper lode occurs in the Rubicon lease a quarter of a mile further south, where the lode is nine inches wide, composed of green and blue chrysocolla, flanked on either side by hornblende crystals ranged at right angles, and often extending through the whole six inches of wall.

At the Rubicon Mine, No. 138D, two parallel lodes occur; the western lode is from five to 12 feet wide, and the eastern lode five to six feet; they junction about 40 feet south of the main shaft; this is 250 feet v.d., but is on the underlay of 78° to west down to the 150 feet level, and thence 54°. Drives extend 80 feet south and 170 feet north of the main shaft, while rich gold-bearing stone was met with at the fork of the reef. The quartz has mostly a bluish tint.

About 15 chains to the east of the Rubicon mine is the Nimrod reef, with a course to west of north.

Nimrod Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
					tons.	ozs.
1891 ...	Nimrod (now San Diego Extended)	...	...	...	30	46·30
					= a yield of 1oz. 10·866dwts. per ton.	

About 15 chains to the southward is the Royal Charter, No. 181D, comprising the extinct lease Groper; it is evidently a continuation of the Rubicon reef. The workings here are down to 100 feet depth. A further continuation of this reef appears again to the

southward in Great Fingall No. 2 Extended; very little work has been done there as yet.

About 30 chains due west from the Royal Charter there are two small parallel reefs in Stern No. 3 Lease, No. 240D, and Stern No. 2 Lease, No. 1029, underlaying west; some shafts have been sunk to about 90 feet depth here. A diamond drill bore has been put down near the centre of Stern No. 2 and reached a depth of 550 feet, passing through a blue black quartz, at a depth of 354-357 feet, carrying a fair quantity of mineral.

In the Fingall Lease, No. 239D, about a quarter of a mile to the south, these two reefs evidently appear again, and they may be identical with the west branch of the Great Fingall reef.

FINGALL REEF.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
1901 ...	Fingall	239D	...	...	**50**	**27·50**
					= a yield of 11dwts. per ton.	
			RUBICON REEF.			
Previous to 1897	Crœsus	14D	762	1,428		
1898 ...	Do.	...	319	320·13		
1899 ...	Do.	...	57	40·68	1,138	1,788·81
Previous to 1897	Rubicon leases ...	138D 166/7D	396	223		
1897 ...	Do.	...	405	320·55		
1898 ...	Do.	...	204·5	145·38		
1899 ...	Do.	...	485	359·67		
1902 ...	Do.	...	360	211·82	1,850·5	1,260·42
1898 ...	Groper, afterwards in part Royal Charter	156D	172	176·22*		
1900 ...	Royal Charter... ...	181D (156D)	85	217·58†		
1901 ...	Do.	...	30	12·10	287	405·90
					3,275·5	**3,455·13**
					= a yield of 1oz. 1·1dwts. per ton.	

* Includes 35·58ozs. dollied specimens.
† „ 34·60ozs. „ „

About a quarter of a mile to the southward from the Royal Charter in the Great Fingall North, No. 189D, is the northern end of the GREAT FINGALL REEF, or a branch of it; the underlay is 70° to the west, and the width five to six feet. The other branch, about four feet wide, was met with in the main shaft. Two vertical bores have been put down on the western side of this lease. A fault appears to occur in the reef at about the southern margin of the

lease, throwing the lode to the south. The reef then increases in width to 15 feet, and curves round to a south-east direction in a distance of 30 chains, the first half of which has a bold outcrop; beyond the 30 chains it disappears.

Near the northern bend also of this large reef a change to a diorite rock occurs, and the reef is cut off along a south-westerly direction by graphitic faces, the quartz also becoming cloudy and dark. The rest of the reef is a clear blueish dark quartz, the gold too finely disseminated to be visible. The Great Fingall mine is situated on this south-east deflection of the reef, and is the most important mine on the Murchison Goldfield, close upon four tons of gold having been procured from it. The old main or Armstrong shaft is 640 feet in depth, cutting the lode nearly at mid distance. The new main or Day Dawn shaft is further to the south, and is connected at the 215 feet level by a crosscut. The underground workings are mostly comprised in the Great Fingall Lease No. 1D, and have been executed in a very methodical manner, assisted by the regularity of the course of the reef and the well-defined walls. At the 640 feet level the reef assumes the phenomenal width of 40 feet of solid quartz. The mine is remarkably free from water. There is a battery of 60 head of stamps here, and eight cyaniding vats of 150 tons capacity each.

A sinuous cross reef, with a splayed underlay to the south, occurs near the Day Dawn shaft. It has been worked to a depth of 200 feet, but the further working will be carried on from the new West Fingall main shaft on the West Fingall reef, bores Nos. 1, 3, and 5 having been put down to depths of 700 feet, 250 feet, and 350 feet respectively, to test the continuation southerly of this reef. It probably crosses to the north side of the Great Fingall Reef, and occurs in the Fingall Cross Reef and Fingall Block leases.

Great Fingall Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Great Fingall Consolidated, Ltd.	1D, 2D, 86/7, 99D, 119D, 129D, 158/9D.	26,666	16,451		
1897 ...	Do.	,,	5,886	5,313·84		
1898 ...	Do.	,,	7,000	5,927·81		
1899 ...	Do.	,,	330	3,594·66		
1900 ...	Do.	,,	4,447	8,525·95		
1901 ...	Do.	,,	39,984	67,044·86		
1902 ...	Do.	,,	75,939	95,937·71		
	48,875 tons tailings			21,213·17		
	689 ,, concentrates			7,159·41		
	190 ,, slag			369·72		
					160,252	231,538·13
					= a yield of 1oz. 8·897dwts. per ton.	

The Great Fingall Reef has been sought for by a diamond drill bore about 400 feet in depth in the Great Fingall South, No. 221D, and by three others in Great Fingall Extended No. 1. The first of these latter is about 100 feet north-west from the west corner of recreation reserve No. 3620 to a depth of 1,200 feet, intersecting a felsitic dyke; and another eight and a-half chains from south-west from the last to a depth of 500 feet; the third bore was being commenced at the time of my visit, in June last, in a line between these two, and five and a-half chains from the former, the intention being to bore vertically to a depth of 2,000 feet. These all have been put down by the same syndicate.

Three other bores have been put down for the same object by the South Fingall, Ltd., one in the South Fingall, No. 217D, vertically to 1,000 feet depth, and another to 2,303 feet in No. 2 South Fingall, with apparently some satisfactory results.

These bores passed through chiefly soft talcose schists, representing foliated and crushed amphibolite rock; these schists are moderately auriferous. The felsite dyke met with in the 1,200 feet bore was also encountered here, but it was found to have tapered out greatly. These bores appear to show that the Great Fingall Reef takes a turn to the south, and is probably identical with the South Fingall Reef.

The SOUTH FINGALL REEF appears at the north corner of South-East Fingall, No. 231D, and outcrops along the east boundary of South Fingall, No. 217D, underlaying to the west about 53°, and it outcrops again about 24 chains to the south; it has here a width of three to four feet; the quartz is dark coloured by iron and manganese. A bore was being put down to test this reef at a depth at the south end of No. 1 South Fingall, No. 219D; to the southward from here the reef passes into the Great Fingall South-West, No. 297D.

The WEST FINGALL REEF, in West Fingall No. 3, No. 158D, has a south-easterly course, with an underlie of 60° to south-west; its width is about two feet and the present depth of workings is 215 feet; two bores, Nos. 2 and 4, have been put down on the south-west side of this lease to depths of 420 feet and 460 feet. The main shaft has lofty iron headgear and is being equipped for very deep sinking. The country rock both here and in the Great Fingall is a massive close-grained amphibolite, altered in places into foliated rock, with green bands of epidote rock.

About 15 chains to the north of the West Fingall reef is the PELICAN REEF: they may be one and the same reef. It is here north and south, and has the same underlie of 60° to the south-west. It traverses the West Fingall No. 8 lease, No. 209D, which comprises the extinct leases, Pelican and Queen's Birthday; the country rock is a slightly decomposed diorite. Further to the west, about 10 chains, is a parallel reef, the WEST FINGALL No. 6, with an underlay of about 50° to west; a shaft of 120 feet deep has been sunk here and over 200 feet length of driving done.

The Smith's United Reef, to the southward, is probably the same line of reef, and is parallel to the West Fingall; it underlays 60° to south-west. The West Fingall No. 9 lease, No. 212D, comprises the extinct Smith's United lease. The workings here, to a depth of 50 feet, produced some good ore.

The Try Again Reefs are two parallel reefs in the Try Again lease, Nos. 267D and 174D, and underlay 80° to the west, with a north and south course.

West Fingall Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Golden Crown (subsequently Great Fingall Deeps)	78D	60	109		
1897 ...	Do. do. ...	...	50	34		
					110	143
					= a yield of 1oz. 6dwts. per ton.	

Pelican Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
Previous to 1897	Cooya	28D	50	40		
1897 ...	Do.	...	35	16·35		
					85	56·35
Previous to 1897	Queen's Birthday South	66	...	...	33	8
1897 ...	Pelican	101D	...	...	25	29
					143	93·35
					= a yield of 13·055dwts. per ton.	

West Fingall No 6.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
Previous to 1897	St. Albans, now West Fingall No. 6	119D	35	12		
1897 ...	St. Albans	...	8	4·8		
					43	16·8
					= a yield of 7·814dwts. per ton.	

Smith's United Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Smith's United Reef, now West Fingall Reef No. 9	146D	44	44		
1897 ...	Do.	...	73·5	236·30		
1898 ...	Do.	...	40	*121·45		
1899 ...	Do.	...	5	2·16		
					162·5	403·91
					= a yield of 2ozs. 9·70dwts. per ton.	

Try Again Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
1897 ...	Perseverance	46D	37	24·30		
1899 ...	Do.	...	11·5	14·60		
1899 ...	Try Again	174D (46D)	15·25	61·31		
1900 ...	Do.	...	28	17·90		
1901 ...	Do.	...	6	7·50		
					97·75	125·61
					= a yield of 1oz. 5·70dwts. per ton.	

* Includes 4ozs. dollied specimens.

The Emperor Reef, nearly one mile south from the west Fingall main shaft, has an east and west course, underlaying 62° to south; the width is about two feet six inches. The main shaft is 200 feet in depth, and is on the underlay. The lode has been driven on for about 200 feet to east and west, and stoped up. A diamond drill bore has been put down on the south boundary of Emperor 15D to a vertical depth of 510 feet. There is a battery here of five head of stamps.

Emperor Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Ore therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Emperor	15D	651	1,964		
1897 ...	Do.	...	952·45	794·83		
1898 ...	Do.	...	25	28·10		
1899 ...	Do.	...	110·25	107·10		
1901 ...	Do.	...	28	14		
					1,766·70	2,908·03
					= a yield of 1oz. 12·920dwts. per ton.	

The TRENTON REEF is situated at the western foot of the Trenton Hill, about 30 chains to the west of the Emperor; its course is a few degrees west of north, and underlays 50° to west. It has a width of about three feet.

TRENTON REEF.

	G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Ore therefrom.
		tons.	ozs.	tons.	ozs.
revious to 1897 Trenton Leases ...	148D	7,732	6,007		
398 ... Do.	...	16	17·65		
399 ... Do.	192D (148D)	12	15		
				7,760	6,039·6
				= a yield of 15·566dwts. per ton.	

About three-quarters of a mile north from the Trenton is the Welcome Reef, underlaying to the west, and three-quarters of a mile further north, and three-quarters of a mile west of the West Fingall No. 6 reef, is the GREAT WESTERN REEF, on which the extinct leases, Great Western and Aurifer, were situated. It has a north and south direction.

GREAT WESTERN REEF.

	G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
		tons.	ozs.	tons.	ozs.
evious o 1897 Great Western ...	125D	20	16		
97 ... Do.	...	17	11·57		
00 ... Do.	...	6	1·05		
02 ... Aurifer	253D	11	3·55		
				54	32·17
				= a yield of 11·91dwts. per ton.	

About a quarter-mile eastward of the railway line at Day Dawn, and situated in amphibolite schist, is what the miners have called the MULLOCKY LEADER. It is a very ferruginous and decomposed lode 15 inches wide; some rich specimens have been obtained from it. It traverses the Phœnix, No. 259D, and Louisa, No. 263D, the greater portion of the latter lease being previously Cue Victory G.M.L. 361. It has a north and south line, and turning north-easterly in the Last Chance, 244D, comprising the now extinct New Caledonia. The underlie is from 50° to 75° to the west.

Mullocky Leader.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	New Caledonia, afterwards Last Chance	157D	70	66		
1897 ...	New Caledonia ...	...	85	22·26		
1898 ...	Do.	...	Dollied specimens	6·15	155	94·41
1899 ...	Phœnix	173D (12D)	40	405·80		
			Cyaniding	299·7		
					40	705·50
					195	799·91
					= a yield of 4ozs. 2·042dwts. per ton.	

Immediately to the north of the Mullocky Leader are the Ballarat and Creme d'Or Reef, 10 chains apart and parallel, with a course of a few degrees west of north underlying west 62°.

Creme d'Or Reef.

		G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
1897 ...	Crême d'Or	22D	21·50	19·30		
1898 ...	Do.	...	134	88		
1899 ...	Do.	...	61	52·91		
1900 ...	Do.	...	26·5	27·59		
					243	187·80
					= a yield of 15·457dwts. per ton.	

The White Horse Reef, in the middle of the Day Dawn municipal area as recently extended, has an east and west course, and shows a large mass of quartz on the surface. The reef underlays south; the surface stone is white, but the workings, about 30 feet depth, show a quartz of a cloudy blue colour, and ferruginous in places at the western end. The western end appears to be only a remnant of the reef, as it has not been found to go down. The adjacent rock is a foliated amphibolite.

White Horse Reef.

	G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
		tons.	ozs.	tons.	ozs.
1902 ... White Horse	238D	...	...	5	6·65
				= a yield of 1oz. 6·6dwts. per ton.	

The Eureka No. 5 Reef is half a mile south-easterly from the last, in a schist which is greatly decomposed. The workings were inaccessible at the time of my visit, but I understand that the reef has been driven on for a distance of 600 feet, and it has been stoped from the 120 feet level to the surface. There is a battery of five head of stamps here, which has yielded the following results. The mine, together with the Rubicon, is under the management of the Murchison Associated Mines, Ltd. :—

Eureka No. 5 Reef.

	G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
		tons.	ozs.	tons.	ozs.
1897 ... Eureka No. 5	26D	151·75	228·92		
1898 ... Do.	...	215	226		
1899 ... Do.	...	582·5	672·85		
1900 ... Do.	...	251	225·9		
1901 ... Do.	...	80	59·95		
				1,280·25	1,413·62
				= a yield of 1oz. 2·082dwts. per ton.	

The Sailor Lad and Edward VII. Reefs and Richmond Reef are nearly north and south reefs, about 25 and 55 chains to the westward of the Eureka. The Edward VII. has yielded some very rich stone; it is a very ferruginous lode. The now extinct Bonnie Scotland lease was half a mile to the north of the Eureka.

Sailor Lad.

	G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom
		tons.	ozs.	tons.	ozs.
Previous to 1897 Sailor Lad	134D	40	55		
1898 ... Do.	...	8	3·6	48	58·6
				= a yield of 1oz. 4·416dwts. per ton	
Previous to 1901 Edward VII.	214D	10	45		
1902 ... Do.	...	30	44	40	89
				= a yield of 2oz 4·5dwts. per ton	
Previous to 1897 Richmond	151D	48	150		
1900 ... Do.	206D (151D)	22	49·15	70	199·
				= a yield of 2oz 16·9dwts. per ton	
1901 ... Bonnie Scotland ...	215D	...	...	6·5	16·
				= a yield of 2oz 10dwts. per ton	

The Kinsella Reef is one mile south-east from Day Dawn, and has a course of a few degrees west of south; it is perpendicular and has a width of six feet; a subsidiary parallel reef occurs on the west side of the main reef. The workings have been confined to the 46 and 100 feet levels; these extend through the greater portion of the lengths of leases No. 179 and 242. They were not accessible at the time of my visit. Extensive preparations are being made to open up this reef at a depth. The country rock is a fine-grained amphibolite, slaty in parts. Two Diamond Drill bores have been put down here to a vertical depth of 700 feet, and a third was about to be begun at the time of my visit in June last. There are three cyaniding vats here, with a capacity of 40 tons each. About half a mile to the north there is a reef with a westerly underlay traversing the Golden Crown lease. The Little Wonder, No. 274D, is on the west side of this reef. A shaft is now being sunk in this lease in amphibolite carrying pyrites.

Kinsella Reef.

		G.M.L.	Gold crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
			tons.	ozs.	tons.	ozs.
Previous to 1897	Kinsella	149D	7,312	3,499·12*		
1898 ...	Do.	...	192·5	88·16		
1899 ...	Do.	...	24	36		
1900 ...	Do.	179D (149D)	106·5	78·88		
1901 ...	Do.	...	cyaniding	111	7,635	3,813·16
1901 ...	Revenue	274D	20	4·7	20	4·7
					7,655	**3,817·86**
					= a yield of 9·975dwts. per ton.	
1899 ...	Day Dawn Public Battery, 10 head of stamps	M.A. 6D	...	...	**100**	**47·74**
					= a yield of 9·548dwts. per ton.	
1902 ...	Do. cyaniding 300 tons tailings	...	..	...	...	**29·90**

* Including 142oz. dollied specimens.

Besides these returns, there are the yields from Quartz and Prospecting Claims from the districts of Cue and Day Dawn, which are not so readily located, nor are they all within the limits of the map of the reefs, nor separated according to the granite and amphibolite areas.

Quartz and Prospecting Claims at Cue.

	G.M.L	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
Previous to 1897	...	tons. unknown tons.	ozs. 572	tons.	ozs.
1897	...	975	992·24		
1898	...	1,179·1	1,029·46*		
1899	...	881·25	742·32†		
1900	...	491·00	433·26‡		
1901	...	62·00	31·15		
1902	...	146	71·47		
				3,734·35	**3,299·90**

* Includes 266ozs. dollied specimens. † Includes 25ozs. dollied specimens.
‡ Includes 23·55ozs. dollied specimens.

Quartz and Prospecting Claims at Day Dawn.

	G.M.L.	Ore crushed.	Gold therefrom.	Total Ore crushed.	Gold therefrom.
		tons.	ozs.	tons.	ozs.
1899	...	213	475·58*		
1900	...	112·5	119·25		
1901	...	39	33·25		
1902	...	5	·60		
				369·5	**628·68**

* Includes 29·19ozs. dollied specimens.

Summarising the above returns we obtain from—

	Tons crushed.	Ounces therefrom.	
Quartz veins in granite	102,329·18	87,551·10	A yield of 17·112dwts. per ton.
Do. amphibolite	194,371·70	261,165·23	A yield of 1oz. 6·873dwts. per ton.
	296,700·88	**348,716·33**	**= 1oz. 3·506dwts. per ton.**

Adding to this the following additional items, for which there are no given quantities of ore treated:— Mystery, 2oz.; Caledonian Hill, 60ozs. sluiced; and Maori Chief, 59oz.; Tailings Area 12, and Machine Area 5, 251·2oz.; Victoria Reef, 277oz.; Quartz and Prospecting Claims, 572oz. = 1,201·2oz.

There is a total of 349,918ozs., or 13 tons 0cwt. 1qr. 12lb. of gold that has been obtained within the area of the map.

W. D. CAMPBELL,
Assistant Geologist.

By Authority: Wm. Alfred Watson, Government Printer, Perth.

H. J. Pether, Government Photolithographer, Perth. W. A.

1903.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 8.

Lennonville, Mount Magnet, and Boogardie,
MURCHISON GOLDFIELD

BY

CHAS. G. GIBSON, B.E.,
Assistant Geologist.

Issued under the authority of the Hon. H. Gregory, M.L.A., Minister for Mines.

WITH A MAP.

PERTH:
BY AUTHORITY: WM. ALFRED WATSON, GOVERNMENT PRINTER.

1903.

CONTENTS.

PREFATORY NOTE.

DURING the year 1902, a short visit was paid by myself to Lennonville with the object of investigating its mineral resources. It was found that the auriferous deposits were of two distinct types, viz., white quartz reefs, and laminated quartz and jasper veins, approaching very closely the hematite-bearing quartzites which form such a conspicuous feature in some portions of the Murchison and elsewhere in the goldfields of the State.

The two types of deposit bidding fair to become of economic importance, it seemed that assistance could be rendered to private enterprise in the direction of mapping and otherwise investigating these formations in the hope of furnishing a reliable guide for the conduct of the operations of the prospector and the mining engineer. A map embodying the results of the work at Lennonville was issued to the public in the month of September last. It was deemed desirable that the extension of these deposits in the direction of Mount Magnet and Boogardie should be mapped and reported upon. This work was intrusted to the Assistant Geologist, Mr. Gibson. The area embraced by his labours extended over about 36 square miles. Upon the map by which the report is accompanied, all shafts, alluvial workings, existing leases, the strike and underlie of the reefs and ore bodies, in addition to the geological boundaries so far as they can be followed, have been shown, thus rendering the map of general utility.

The main auriferous series of Lennonville, Mount Magnet, and Boogardie is enclosed in a belt of more or less highly altered rocks, for which the term greenstone has been provisionally adopted. Under this head are included diorite, diabase, pyroxenite, together with hornblende and chlorite schist, which may merely represent the crushed or plated out variety of the former, induced by shearing, and possibly modified by chemical action. The greenstones are traversed by belts of laminated quartzites, which rise up from the surrounding country in the form of low, often serrated, ridges. These quartzites are intersected by numerous faults, the mapping of which is of considerable importance from a mining point of view, in that it is along these lines that the rich chutes of gold, for which the district is noted, occur. The bulk of the gold has been found to occur in chutes where the faults intersect the quartzites. Wherever visible, these faults cross the strike of the

quartzites approximately at right angles, and as the latter are generally only from 30 to 60 feet in width, it necessarily follows that the width of the chutes is small. The quartz reefs occur plentifully in both the granite and the greenstone area, though, as a rule, it is only in those occurring in the latter which have proved to be auriferous to any extent. The quartz reefs often form the continuation of the fault lines by which the laminated quartzites are crossed.

It is highly desirable, in the interests of the State, in view of the light conferred by the recent work in the Mount Magnet district, that when opportunity offers the northern extension of this auriferous belt should be geologically examined with the view of showing its relation to the deposits of Nannine, Meekatharra, and other localities in the North Murchison district.

The report and accompanying maps, on being submitted to the Hon. the Minister for Mines, were ordered to be printed for public information.

A. GIBB MAITLAND,

Government Geologist.

Geological Survey Office,

Perth, 6th June, 1903.

Lennonville, Mount Magnet, and Boogardie.

Murchison Goldfield.

The Murchison Goldfield, as originally constituted, was first proclaimed on 24th September, 1891. Its boundaries were modified on 15th February, 1895, so as to embrace an area of about 21,000 square miles. As defined by the authorities, the goldfield at present is:—

> "Bounded by lines starting from the summit of Mount Murchison and extending north-eastward to the summit of Mount Hale; thence east-south-eastward to the summit of Mount Russell; thence south-westward to the north-west corner of the Yilgarn Goldfield; thence west-north-westward to the summit of Wyemando Hill, and onwards to the trig. station K. 6 on Goonamondey Peak; thence north-westward to the summit of Mount Farmer; and onwards to the summit of Mount Luke, and onwards to the summit of Mount Murchison."

Extent of the Map.—The map of Lennonville embraces a tract of country extending about one and a-half miles north, three and a-half miles south, two and a-half miles west, and one mile east from the Lennonville Post Office; that of Mount Magnet-Boogardie, a tract extending about two and three-quarter miles north (coterminous with the Lennonville map), two and three-quarter miles south, four miles west, and two and a-half miles east from the Mount Magnet Post Office. On these maps are indicated all shafts, alluvial workings, the positions of existing leases, the strike and underlie of all reefs and ore bodies, and, in addition, all geological boundaries so far as they can be followed. These latter are, in places, only approximate, owing to their being hidden by considerable areas of recent superficial deposits derived from the residual weathering of the older rocks. The thickness of the cover of superficial deposits varies from a few inches up to a maximum of about 20ft. Its extent is not shown on the maps owing to the fact that its boundaries are very ill-defined, and also that in most cases its thickness does not exceed a few inches, thus rendering it not worthy of consideration.

History of the Field.—Very little has been written about the early history of the Murchison Goldfield; the following brief account, however, has been taken from Kimberley's "History of Western Australia," published by subscription in the year 1897:—

"The first place at which gold was discovered on the Murchison was at Yuin—a place long since abandoned—but the first find of any real importance took place at Nannine. . . . The field was first proclaimed in 1891. . . In 1893 the gold returns of the Murchison fell short of those of 1892 owing to the fact that a large number of miners were leaving for the Coolgardie field. . . . Quartz claims were opened up at several places, a long distance apart, on the Murchison, and a number of gold mining companies were floated. Alluvial still yielded the largest percentage of the output, and rich finds were made at Mount Magnet, Austin's Lake, Nannine, and Cue. The two chief centres at this time were Nannine and Cue. The former township was laid out, declared and excepted from occupation for mining purposes on 20th April, 1893, and the latter on 10th August of the same year. E. P. Dowley became Warden, the Warden's office was removed from Nannine to Cue, and the goldfield was proclaimed a magisterial district. Crushing operations were begun this year (1893); stampers were erected on the Star of the East, near Nannine, and also at Mount Magnet and Cue. Good supplies of fresh water for battery purposes were obtained at various places on the field, notably at the Star of the East, the Day Dawn (Cue), and the New Chum (Mount Magnet). The Government sank wells at Day Dawn, Cue, and on the road from Nannine to Abbotts. In each case good water was secured. Eighty-one gold mining leases were applied for on the Murchison in 1893, and 40 business licenses were issued. In January, 1893, the Government offered a bonus to any company or person who would sink a shaft below a depth of 100 feet in any proclaimed goldfield; £2 10s. per foot from 100 to 200 feet, and £5 per foot below 200 feet. During the year the sum of £1,734 was paid to 11 claimants—six at Yilgarn, one at Coolgardie (Bayleys, 180 feet), and four on the Murchison. The Blackbourne (267 feet), had the deepest shaft on the Yilgarn field, and the Black Iguana (174 feet) the deepest on the Murchison.

"Developments on the fields in 1894 far exceeded those of 1893. No phenomenal finds were made as on the Eastern Fields, but a considerable amount of machinery was erected on the mines. A Warden's Court was opened at Yalgoo in August, and the Court at Lake Austin was closed. The average of the stone crushed was very encouraging, and the alluvial also yielded some fair returns in 1894. The total output for the field was 52,946·30ozs., valued at £201,196.

"In 1895 the Murchison Goldfield became so active that the southern portion was separated from the northern, and called the Yalgoo Field. The mining population of this district was about 750. There were 17 batteries at work round Cue, nine round Nannine, and two at Mount Magnet. At Kalgoorlie the best

returns were being obtained, while at Cue and Day Dawn the best machinery was engaged. The towns of Austin and Mount Magnet were proclaimed in 1895, the former on 31st May, the latter on 18th January. The number of miners engaged on the Murchison in 1895 was 2,200."

Previous Observations on the Geology of the Murchison Goldfield.—In his Mining Handbook* Mr. H. P. Woodward, late Government Geologist, refers the rocks forming the greater portion of Western Australia to the Archean age. According to his account these Archean rocks are usually crystalline, and are found outcropping throughout the State, and being overlaid only in isolated places by much newer formations: these latter rarely of any great thickness. The Archean rocks he divided into three sections, the granites, the gneisses, and the schists, which, as a rule, run in parallel belts north and south, with a slight trend to the north-west. These belts are six in number.

"The fourth, or first auriferous belt, is situated immediately to the eastward of the granite belt, and is about 20 miles in width. It starts from the south coast, at the Phillips River, extending northward in a narrow belt by the Ravensthorpe Range, Parker's Range, Southern Cross, Golden Valley, Mount Jackson, Mount Kenneth, Mount Magnet, Austin's Lake, to Cue; thence it takes a slight bend to the north-east to Nannine and the Star of the East, where it strikes more to the north, and, skirting round the heads of the Murchison and Gascoyne Rivers, it turns north-west and follows down the Ashburton Valley to its junction with the Henry, finally disappearing beneath the palæozoic formations.

"The rocks of this belt consist mostly of hornblende, mica, or talc schists, of which the hornblende schist so closely resembles diorite that it is impossible to distinguish it in a broken specimen. . . . . . . The rocks of this belt are a good deal broken and faulted by granite and diorite dykes and quartz lodes containing gold, iron, and copper. There are also some large magnesia lode masses, rich in fine gold, which will probably prove to be serpentine at a depth. Many of the lodes also contain large quantities of chlorite."

In his report on the Murchison Goldfield,† the same writer says:—"The principal auriferous belt is situated at the eastern side of this area" (*i.e.*, the proclaimed goldfield area), "about 200 miles from the coast; it runs in a north and south direction from West Mount Magnet to Austin's Lake, then in a north-easterly direction to Lake Anneen and Yagahong. Other rich patches and belts exist further east, and a few patches have also been discovered near the coast. . . . . . The geographical features of the portion of the field on which gold has been discovered are not very

* "Mining Handbook to the Colony of Western Australia" by H. P. Woodward, F.G.S., Government Geologist, Perth. By authority: Richard Pether, Government Printer, 1895.

† Report on the Murchison Goldfield, by H. P. Woodward, F.G.S., Government Geologist, Perth. By Authority, 1893.

striking, being only the ruined remains of a vast, high, sandy tableland presenting to-day a broken surface consisting of salt marshes or lakes fringed by salt, sand, clay, and gypsum flats, from which rise low rough ridges of metamorphic rocks or white cliffs, on the top of which are sandy plains—the remains of the ancient tableland. There are no well-defined rivers, but the few creeks discharge themselves into the salt flats, where the water evaporates, except after very heavy rains, when they overflow into the rivers which run towards the coast. The hills are mostly small and low, consisting for the most part of ridges of hard metamorphic rocks, near which the rich finds of gold have been made. These are often capped by the same horizontally bedded formation exposed in the cliffs on the edges of the broken tablelands, which are generally covered by dense thickets of low scrub.

"The metamorphic rocks outcrop, rising as low ridges, wherever the overlying desert sandstone tableland has been removed; they are mostly hard large quartz reefs, often forming the axes of the ridges, but more generally beds of highly altered ferruginous quartzite, nearly approaching a mineral vein in character, at their intersection with which the quartz reefs are always the richest.

"Along the principal belt of auriferous country, the rocks for the most part strike a little to the west of north, and underlie to the westward, consisting largely of talcose and granitic rocks, although hornblendic and micaceous slates are also met with. Where there are patches of limestone, the surface is covered by travertin deposits, and the veins are mostly of a ferruginous calcite, in some of which gold has also been found.

"The rocks at the north end of the field take a sudden turn to the north-east and east. Dykes are met with in many places; these are generally either granite or diorite, the latter being of great variety, while the former generally contain crystals of foliated talc in cavities.

"The mineral veins consist mostly of quartz, but ferruginous lodes and veins of calcite and dolomite also exist. The quartz is of great variety, from pure white with talc in the white granite country, to white, blue, and highly mineralised in other places; whilst the calcites and dolomites are mostly ferruginous.

"Where the reefs have been opened up to water level, many of them contain galena as well as iron pyrites, and the veins seem for the most part, as far as one can judge at present, to be true fissure veins, most of them probably continuing in depth; but they will vary greatly in size, direction, and thickness, and many will have to be traced by a mere line or face for a considerable distance.

"The veins rarely follow the strike or dip of the other rocks, but cut across them in all directions; and when they are lost at the ends they generally seem to turn and strike along the line of bedding of the rocks as a mere thread for sometimes a considerable distance, making again into a large body of stone, when they strike off again more or less on their old course. The reefs are found to

be very rich in chutes, the gold being mostly met with at the intersection of certain beds, whilst at other places either large bodies of stone or pinches are accountable to the same cause. The question as to which are the true veins cannot be decided until a more systematic survey of the field has been made; but in most cases where there is a large main line of reef parallel lines are met with which it is quite impossible to trace for any distance; these latter are in all probability not true veins, but only infilled lateral fissures, which, although often very rich, will not extend for any distance either along the surface or in depth.

"The main lines of reef seem to follow a more or less north and south course, but there are some very rich ones which strike east and west; these also vary greatly, some being small cross-courses, extremely rich at their intersection with the main north and south reefs."

Continuing, the same writer says:—"The Mount Magnet diggings are situated a few miles to the south and west of West Mount Magnet, which hill is principally composed of metamorphic rocks, capped by a flat top of desert sandstone.

"The rocks strike mostly a little west of north, and dip to the westward. They are slate, dolomite, talcose schist, and ferruginous jaspery quartzite, all of which are very decomposed.

"The reefs follow much the same strike as the rocks, and dip also to the westward. They are small but well defined, and in some places appear to carry gold pretty well through the stone. The quartz is mostly white, and rather greasy, with ferruginous stains and yellow clay partings; but nothing very rich has been found in the reefing line on this part of the field, except the Monarch Mullocky Leader, which is not a true reef, but a mass of decomposed talcose schists, through which there are a number of small ferruginous quartz veins. The whole mass carries fine gold, but up to the present only the soft part has been worked, and has proved very rich in gold. On the surface here a small but very rich patch of alluvium was worked along the side of a large ferruginous quartzite bar.

"All the alluvial work here has been surfacing, the patches being worked by dryblowing places where a mixture of quartz and ironstone are found scattered over the surface.

"A good deal of gold will probably be found around here, but most of the men are away on the rich finds further north."

Geology of the Field.—The following is a description, based on personal observation, of the geological and cognate features of that portion of the Murchison Goldfield embraced within the boundaries of the accompanying maps.

General Topography.—Taking West Mount Magnet as a starting point, the country from east through south to south-west consists of a level plain covered with a shallow deposit of recent beds,

the plain being sparsely timbered with stunted mulga. This plain, which extends south and south-east for 20 or 30 miles, is bounded on the east at a distance of some two or three miles south-east from Mount Magnet by a ridge of granite hills, which, at a point about due east of the mount, merges into a tableland which runs northerly for a distance of some six miles, when it turns away easterly and continues on this bearing for some miles. This tableland is covered with a shallow deposit of sandy soil, derived from the denudation *in situ* of the granitic rocks of which it is composed. It presents on its western and northern edge a more or less vertical cliff face of some 40 or 50 feet (which may mark a line of fault), rising abruptly out of the surrounding plain.

About six miles south-west from Mount Magnet is a low ridge of rough quartzite hills, rising some hundred feet above the surrounding flats and trending from south-west to west some three or four miles, at which point it joins the range of hills coming in from the west of Boogardie.

The country to the north is more broken than to the south, and consists of a series of low, rough quartzite ridges, running slightly west of north, and of isolated greenstone hills, which latter often rise to a height of 150 feet, and are generally capped by a considerable thickness of ironstone conglomerate; they are often flat topped with vertical faces for some 20 feet from the top. The country between these hills and ridges consists of flats covered with red soil derived from the weathering of the older greenstone rocks.

To the west of the Mount, and in the neighbourhood of Boogardie, the country is rough and hilly, consisting of numerous quartzite ridges running for the most part in a general north-westerly direction. These ridges attain their greatest elevation some two or three miles west of Boogardie, where they rise to a height of 150 to 200 feet.

West Mount Magnet itself, the highest point in the district, is a rough round-topped hill 250 feet high, forming the south-western end of a long quartzite ridge.

General Geological Features.—A belt of more or less highly altered greenstones comprises the main auriferous series which extends in a general northerly direction from West Mount Magnet, past Moyagee, as far north as Lake Austin and the town of Cue. This belt, at a point two or three miles south from Mount Magnet townsite, attains a maximum width of some 15 miles, narrowing rapidly as it runs north, till at a point about half-way between Mount Magnet and Lennonville it is only some five miles across. From this point it widens again to 10 or 12 miles, and continues northerly at this width beyond the limits of the map.

This belt of rocks, to which the general term of "greenstone" has been given, comprises diorite, pyroxenite, altered pyroxenite, together with hornblende and chlorite schists. Owing to the paucity of natural sections, it has been found impossible to distinguish on the

map the relative area occupied by each, and mining operations have not been carried sufficiently far to afford much assistance in this direction.

The rocks naturally vary considerably both in colour and texture, the diorites being the more coarse grained. These are found principally at the southern end of the field, while the rocks at the northern end consist mainly of pyroxenites, a section of which (G.S.M. 3963), seen under the microscope, shows it to consist entirely of a colourless to pale-brown augite, passing in places into a pale green fibrous hornblende. Both the diorite and the pyroxenite occur only over small areas, the greater mass consisting of a considerably foliated rock which appears to be a highly altered form of the latter.

These greenstones are intersected by numerous faults, and they are also traversed by belts of banded quartzites, which rise up from the surrounding country in the form of low, rough ridges, having a general north to north-west trend. These quartzites are especially abundant in the neighbourhood of Boogardie and along the western boundary of the greenstones occurring to the south from this place; they also occur largely on the extreme south-eastern edge of the greenstone belt. The central portion of the district south from Mount Magnet is very free from them, except at the "Six-mile," where a belt of quartzite, forming a bold outcrop, strikes south-west. All these quartzites, occurring to the south of an east and west line passing through Magnet Hill, are highly impregnated with oxide of iron, and in places are distinctly magnetic. North of this line they are practically non-ferruginous. After extending for about six miles northerly, in the form of low parallel ridges, they die out completely, reappearing again some 15 miles further north, where they are once more of the iron-bearing variety.*

It is within this greenstone belt that the gold-bearing reefs and lodes occur. These vary greatly both in size and in the direction of their strike. The largest and richest lines of reef, however, generally run in north and south directions.

The greenstones are bounded on either side by belts of intrusive granite, intermediate between the two being a narrow belt of highly foliated and contorted hornblende and chlorite schists, which pass imperceptibly into, and appear to be merely a localised alteration of, the former. This belt of schists has an average width of some 20 chains. The junction of the granite with the schists on the western side runs in a comparatively straight line on a general north to north-north-west bearing. It is, however, somewhat uneven, small tongues of granite, approaching aplite in composition, running out from the main body into the schists. The junction line on the eastern side is more irregular, varying from almost east and west, at a point due east from Mount Magnet, to north and south a little further north. It has, however, on the whole a general north and south trend. A long tongue of granite runs out

* These quartzites will be found more fully described under "Reefs and Lodes."

from the main body, at a point some two miles east of Mount Magnet, southerly into the greenstones. This tongue, at the point where it leaves the main body, is about a mile across, and runs south for some five or six miles, gradually dying out below the alluvium of the plains. There are, also, numerous dykes of intrusive granite in the greenstones, especially in the southern end of the district. These dykes are finer in texture than the main granite bodies, and in places approach closely to a felsite in general appearance. The main body of granite is a coarse-grained biotite variety (G.S.M. 3960), a section of it seen under the microscope showing it to consist of quartz, felspar, principally plagioclase, together with a little microcline, biotite, and little magnetite; the biotite being very abundant, and occurring in large tabular crystals. It appears to be undoubtedly of intrusive origin, the greenstones being highly foliated and contorted near their junction with it, the schists usually dipping away from the granite. Patches of greenstone schists are also found caught up in mass of the granite itself. A large mass of undoubtedly intrusive granite occurs near Moyagee; this is some ten miles long and several miles across, and is entirely within the greenstones, which have their usual contorted appearance near the junction.

The greater part of the country to the south and south-west of Mount Magnet is covered by shallow recent accumulations, consisting of red sandy soil, resulting from the gradual denudation of the older greenstone and granitic rocks *in situ*. This deposit is of very limited thickness, and rarely exceeds 15 to 20 feet.

There is another class of recent formations found in the district; these are the ironstone gravel deposits (laterite); they occur only over very small areas, generally as the cappings of hills, and consist of nodules of siliceous limonite and hematite cemented together with ferruginous silica and clay. They are probably formed by the gradual concentration of ferric oxide, resulting from the local decomposition of rocks rich in iron. The majority of them are of poor quality, and their actual iron contents low.

There are, however, two small deposits of this class, which are considerably above the average in their iron contents; they occur in the neighbourhood of Boogardie; one on the east side of the Eclipse Hill and the other on the north-east side of the Havelock Hill, and are very limited in extent, having only an area of a few square chains. An analysis made in the Geological laboratory of a sample of the former of these (G.S.M. 4372), taken from G.M.L. 635M, gave results as follows:—

Metallic iron	51·67	per cent.
Silica	11·46	„
Sulphur	·084	„
Phosphorus...	·023	„
Combined water	2·67	„
Moisture	·19	„

When the ironstone gravels occur as the cappings of hills, they generally have vertical cliff faces for a height of 20 to 30 feet; these faces are broken by numerous small caves, in which an impure

natural bitumen is often found. This bitumen, which is taken by many of the prospectors to be an indication of the presence of mineral oil in the surrounding rocks, is probably, from its mode of occurrence and general appearance, merely a decomposition product of the excrement of wallabies and kangaroos, by which these caves have been largely used.

Reefs and Lodes.

Banded Quartzites. — These are of two varieties, the "hematite bearing" and the "non-hematite bearing." The former is the more prevalent type, and occurs principally in the neighbourhood of Boogardie. They will during the remainder of this report be spoken of as the "Boogardie" type. The "non-hematite bearing," or "Lennonville" type, as they will be called, occur only within the Lennonville district, and in small areas at the Morning Star, Paris, and Hector Hill G.M.Ls. in the Mount Magnet district; they are much more limited in extent than the "Boogardie" type. They occur as low, rough ridges of hard compact black and white, or brown and white, quartz, outcropping in belts, generally from two to four chains in width, and with a vertical dip. On breaking through the hard upper surface of these belts they are found to alter greatly in appearance, changing in a few feet from hard compact quartz to alternating thin bands of hard white to grey quartz and soft kaolin. These quartzites invariably carry gold, but not always in payable quantities; there are, however, in them numerous rich chutes, which are being worked with satisfactory results, the gold being found both in the quartz and the kaolin.

The "Boogardie" quartzites differ from the preceding, in that they are more compact at a depth, and are highly impregnated with oxide of iron, usually hematite, but often also with magnetite as well, when they are naturally highly magnetic and render it utterly impossible to use a compass with any degree of accuracy in their vicinity. They also usually carry a considerable amount of pyrites at a depth.

These quartzites are of two varieties: one in which the quartz and iron oxides are in well-defined alternate thin layers, the iron being the predominating mineral; and the other in which the quartz predominates, and the lamination is not so pronounced, a broken specimen having almost the appearance of a highly ferruginous compact quartz. This latter variety, the so-called "jasper" of the local miners, is especially abundant about Boogardie, where the beds run in a series of north-north-west and south-south-east ridges. They differ from the "Lennonville" quartzites in their mode of occurrence, in that they run in a series of narrow parallel bands from one-half to one chain in width, as many as 12 of these bands outcropping along the top of a single ridge, whereas those of Lennonville run in single wide bands, often five to ten chains across. They further preserve their compactness as far as any depth yet reached; none of the kaolin, which is characteristic of the latter

type, being present. They are traversed by numerous faults, the displacement in almost every case being to the right. It is only along these faults that the rich chutes of gold, for which this district is noted, occur.

The following are three partial analyses of samples of these hematite-bearing quartzites made in the Geological laboratory:—

G.S.M.	4377	4384	4376
Metallic iron ...	50·55 ...	32·83 ...	26·63
Silica	24·26 ...	52·50 ...	61·13
Sulphur	·029 ...	·017 ...	·019
Phosphorus ...	·042 ...	·072 ...	·028
Combined water ...	2·94 ...	1·33 ...	·66
Moisture	·41 ...	·08 ...	·07

The numbers (G.S.M. 4377, etc.) refer to the Geological Survey Museum Register. G.S.M. 4376 is a sample taken from the top of West Mount Magnet; G.S.M. 4384 is from a dump on the Havelock G.M.L.; G.S.M. 4377 is from a spot half a mile north-west from the Trig. Station, K. 5.

The manner in which the gold is found in these two types of quartzites differs considerably. In the Lennonville district the gold is obtained in the main body of the quartzites themselves, generally occurring in chutes, some of which are of considerable extent. In the Boogardie district, on the other hand, the quartzites carry but a very slight trace of gold, and it is only in one or two places at the northern end that they are rich enough to pay for working. The bulk of the gold is obtained in rich chutes, occurring in the faults crossing the quartzite bars. These faults cross the bars almost at right angles, and as the latter are generally only from half to one chain in width, the chutes are of necessity short, as they are never found to continue into the country rock, being invariably restricted to the limits of the quartzite bar. The fissures produced by these faults are invariably filled with brecciated quartzite, cemented together with chalcedonic quartz, and traversed by small irregular quartz veins. It is in this quartz that the majority of the gold occurs. The fissures vary considerably in size, but usually range in width from three to six feet. The walls are sharp and well defined, consisting of hard compact quartzite, and usually, like the main body of the bars, carry only a slight trace of gold. These fault fissures are very numerous round about Boogardie, occurring every few chains along the main lines of quartzites; they invariably carry gold, some being extraordinarily rich in places, whilst others again contain only a trace.

The main bands of quartzites appear to have been old fault lines or joints, along which the original greenstones have been highly foliated parallel to the line of faulting or jointing, and thus formed zones of weakness, along which thermal solutions containing silica, iron, etc., have forced their way to the surface, and gradually converted the original foliated greenstones into their present form. This appears to be borne out by the fact that they almost invariably run with the general strike of the country, viz.,

about north-north-west and south-south-east, and also that in several places they can be seen to tail out and insensibly pass into foliated greenstone.

In his report* on the Island Lake Austin, Mr. Woodward, late Government Geologist, writing of the quartzites in that locality, remarks :—" The banded quartz reefs are the main feature of this district, being met with both at Mount Magnet and Nannine, as well as at the Island. They generally rise above the surface as rough rock ridges, which rarely extend half-a-mile in length ; they do not follow one main fissure line, but lie a little to the east or west, as the case may be. At the surface they appear to consist mostly of banded ironstone with jasper veins, but when cut below water line they prove to be banded blue and white quartz, containing considerable quantities of pyrites in places. These lodes, although poor, always contain a small quantity of gold, and invariably exercise considerable influence upon the richness of the quartz reefs of the district, which rarely contain gold except when in proximity to them."

It will be thus seen that these Lake Austin quartzites differ slightly from those of Boogardie which preserve their hard compact ferruginous character as far as tested in depth (about 130ft. below water level).

Quartz Reefs.—Quartz reefs occur plentifully both in the granite and in the greenstones, and are found to vary considerably both in size as well as in the direction of their strike. Generally speaking, it is only the reefs in the greenstones which have proved to be auriferous ; they are for the most part small and usually trend a little to the west of north, and the east of south, and can rarely ever be followed for any great distance. There are a few east and west reefs, but these are generally found to be much poorer in their gold contents than those trending north and south. There are several very large white quartz reefs following the junction line of the granite on both sides of the greenstone belt. These, however, as far as tested, have proved to carry no trace of gold. In the auriferous reefs the gold is very often found to occur in chutes, which, although generally short, are frequently very rich.

Associated Minerals.—Pyrites occurs in more or less quantity in most of the quartz reefs throughout the district, and also in considerable quantities in the ferruginous quartzites round Boogardie, being generally found at or below water level. It is almost invariably found to carry gold.

Stibnite is found in small quantities in the ore bodies at the lower levels of the Morning Star G.M., Mount Magnet.

Pyrolusite is also found in small quantities in the lode stuff in the lower levels of the Hesperian G.M., Boogardie.

* The Island Lake Austin. Annual Progress Report of the Geological Survey for the year 1901. Perth : By Authority : 1902, p. 12.

An alloy of gold and mercury is reported to have been met with in the Havelock G.M., Boogardie.

Water.—The field as a whole is well watered, and as a rule abundance of good fresh water can be obtained at a depth of from 80 to 130 feet. There are, however, one or two exceptions, notably the Long Reef G.M. at Lennonville, and the Morning Star G.M. at Mount Magnet, where the supply is somewhat salt. It is, however, suitable for battery practice, for which purpose it is being used on both mines.

Timber.—Timber for mining purposes and for fuel is rapidly becoming a very serious item on the field. There is nothing but mulga in the district, and this has now to be brought in considerable distances, principally by means of camels.

The Mines.

The following is a brief description of the principal mines working in the district at the time of my visit (November, 1902). There are probably a few mines whose names do not appear on this list; this is because I was at the time unable to examine them owing to the fact that many were either abandoned, under exemption, or otherwise inaccessible.

MT. MAGNET DISTRICT.

Morning Star G.M.Ls. 314m, 317m, 320m.—This property, which is at present the most important in the Mt. Magnet district, has its workings down to a vertical depth of about 350 feet. Two lines of reef are being worked. The main one, known as the "Star" lode, consists of a large irregular quartz reef running about north and south; this reef is as much as 12 feet in width, but is not at all uniform either in size or in its gold values. The second lode, known as the "Easter" lode, is some 10 chains to the east of the main reef, and consists of a belt of very broken banded quartzites some 30 feet in thickness and also running north and south. Some very rich stone was obtained from this lode near the surface. The main shaft has been sunk on the "Star" lode to a depth of about 350 feet, and levels and crosscuts put in at 100, 200, 250, and 300 feet, and a large amount of stoping done, principally on this line of reef. A plentiful supply of water was struck at about 110 feet; it is, however, somewhat salt, this being one of the very few mines in the district in which fresh water was not obtained. The total stone crushed to the end of 1902 is 69,968·00 tons for 44,767·96ozs., an average of ·64oz. per ton.

Iguana G.M.L. 457m.—On this lease two vertical shafts have been sunk, about 150ft. apart, on a small north and south quartz reef. A connecting drive has been put in at the 90 ft. level, and the reef stoped out to the surface. The reef is about 12 inches wide at its outcrop, widening to two feet at the bottom of the workings, and dips about 53° to the east. The country is soft decomposed greenstone, and carries a small amount of gold for

about 12 inches on each side of the reef. Water was struck at about 75 feet, the supply being brackish. At present a new vertical shaft is being sunk on the hanging wall side of the reef to cut it at about 200 feet. The average yield for the last two crushings was 1oz. 3dwts. per ton. The total stone crushed from this mine to date is 348·00 tons for 427·20ozs., giving an average of 1·22ozs. per ton.

Britannia G.M.L. 545m.—This property is situated near the "Six Mile," some five miles south-west from Mount Magnet. On it a main shaft has been sunk to a vertical depth of 90 feet on a lode formation, consisting of a soft decomposed schist highly impregnated with quartz. This lode is about 15 feet wide and runs east and west. A drive has been put in for a distance of some hundred feet at the 50-ft. level, and a considerable quantity of stone raised. A good supply of fresh water has been struck at 50 feet, and most of the stone raised is now being put through a horse puddler with satisfactory results. A crushing of 25 tons put through the Boogardie public battery lately gave an average return of about 1½ozs. per ton. A large quartz reef runs north and south through the property near the eastern boundary, dipping about 60° to the west. This reef is some 12 feet wide, and an underlie shaft has been sunk on it to a depth of about 40 feet. No further work has been done on it as the gold contents are low. Crushings to end of 1902, 176 tons for 168·77ozs., giving an average of ·96oz. per ton.

Comet G.M.L. 489.—Several small ferruginous quartzite bars run through this lease in a north-west and south-easterly direction. On one of these a vertical shaft has been sunk to a depth of 60 feet, and on a second a shaft and open cut have been put down some 30 feet. This bar is from two to three feet wide, and dips to the north-east at an angle of about 75°. The gold in these bars is very patchy, but some very rich specimens have been taken out. The total stone crushed to the end of 1902 is 65 tons for 54·47oz., including 3ozs. dollied; an average of ·83ozs. per ton.

Cushie Doo G.M.L. 490.—Three shafts are down on this property, all to a depth of about 65 feet; of these two are vertical and one underlay. A crosscut has been put in at the 65 feet level easterly between the underlay shaft and one of the vertical ones, a distance of about 50 feet, and also westerly for about 30 feet. The country consists of soft kaolinised greenstone, and is traversed by numerous north and south faults. Small bunches of mixed kaolin and quartz occur on the faces of these faults, and carry considerable quantities of gold. It is these bunches that are being principally worked at present, though work is also being done on a fair-sized north and south body of banded quartzites. This, however, is of low grade, and not of much value as far as prospected. The stone crushed from this mine to the end of 1902 was 104 tons for 285·15ozs., including 87·80ozs. dollied and specimens, giving an average of 2·74ozs. per ton.

Paris G.M.L. 476.—There is a large banded quartzite lode, similar to the Lennonville quartzites, on this lease, the width of which has been proved to be not less than 60 feet. There are two old shafts on this lode, the most southerly of which is down to a depth of 130 feet. Short east and west drives were put in from this shaft at 30, 60, and 10 feet. It was then abandoned and is now full of water to 105 feet. The stone taken out of this shaft averaged from 4 to 8dwts. per ton. From a second shaft further north on the same lode some 200 tons of stone were taken out between the surface and 50 feet, and crushed for an average yield of 25dwts. of gold per ton. The lode is now being worked from a shaft sunk to a vertical depth of 50 feet on the eastern side near the centre of the lease. The stone from this shaft is expected to average from 4 to 10dwts. per ton. The total stone crushed from this mine to date is 662·00 tons for 370·61ozs., an average of ·56oz. per ton.

Monarch G.M.L. 523.—This property was abandoned at the time of my visit, but Mr. H. P. Woodward, late Government Geologist, in his report on the Murchison Goldfield, thus describes it:—"On this area a mass of decomposed talcose schist, with small ferruginous quartz leaders, often jaspery, is being worked. The gold is mostly very fine, but it is plainly visible on the faces of the schistose rocks and all through the quartz, many specimens being extremely rich. There is a large mass of this gold-bearing material, but the full extent is not at present known. The country strikes a little west of north, and dips to the westward at a high angle. . . A very great deal of gold has been got from this claim by simply puddling and washing the decomposed rock, whilst the stone has been reserved for crushing." . . . Total crushings, 365 tons for 202·15ozs., being an average of ·55oz. per ton.

BOOGARDIE DISTRICT.

Boomer G.M.L. 522m.—There are three shafts on this property, a main vertical shaft, down 105 feet, and two underlay shafts, 70 feet—all working on a large ferruginous quartzite bar, running about north-west and south-east, and dipping to the north-east at an angle of 75°. This bar is from 30 to 40 feet wide, and on the eastern side is soft, and broken for a thickness of some six feet. This portion carries the best gold, and averages about 8dwts. for the whole width, the richest stone being got on the extreme eastern edge. The remainder of the bar carries but a slight trace of gold. The gold-bearing portion of the lode has been stoped out for about 50 feet at the northern underlay shaft, small patches of it being very rich. The main vertical shaft has been sunk on the hanging wall side of the lode, and a short drive put in to cut the bar at 105ft. The country consists of soft decomposed greenstone. Good water was struck at 105ft. Total stone crushed, 209 tons for 39·87ozs.; an average of ·19oz. per ton.

Golden Stream G.M.L. 548m. — Four parallel vertical quartzite bars run through this lease in a north-westerly and south-easterly direction. On the most easterly of these, three shafts have been sunk to a depth of 65ft. From the middle one of these two sets of levels have been driven along the eastern side of the bar; the upper, at 50ft., has been driven some 75ft. northerly, while the lower, at 65ft., runs for some 400ft. northerly and about 150ft. southerly. The ore body consists of a mixture of quartz and honeycombed quartzite attached to the eastern side of the quartzite bar. It varies in thickness from a few inches to as much as 4ft. Its gold contents are patchy, ranging from a few dwts. to several ounces, the average being 8dwts. to 10dwts. The quartzite bar itself, as usual, carries only a very small amount of gold. Several lines of fault cross the bars in an east and west direction, and generally throw them to the right; the throw, as a rule, being only a few feet. A small granite dyke runs parallel to the bar some 20ft. to the east. The country is soft decomposed greenstone. A plentiful supply of fresh water was struck at 65ft. The total stone crushed from this lease, to the end of 1902, is 683·50 tons for 355·54ozs., being at the rate of ·52oz. per ton.

Caledonia G.M.L. 607m.—This property adjoins the Golden Stream on the north, and is on slightly higher ground. A vertical shaft has been sunk to water level (85ft.) on the eastern side of the same quartzite bar as the Golden Stream workings are on, and two drives have been put in some 20 or 30 feet northerly along the bar at 60 and 85 feet. The ore body, which is small, is the same as in the Golden Stream. Crushed 15 tons for 2·35ozs., being at the rate of ·16oz. per ton.

Havelock G.M.L.—There are six shafts down on this lease, working on a series of parallel quartzite bars running in a north-westerly and south-easterly direction. The deepest of these is down about 135ft. to water level, the others being all from 100ft. to 110ft. in depth. Altogether three separate bars are being worked; these average from 20ft. to 30ft. in width, and are some 60ft. to 80ft. apart. They carry gold for their full width, having an average value of about 6dwts. Crosscuts have been put in east and west to connect several of the shafts at 100ft., and at this depth levels have also been driven some 100ft. or so along the bars both northerly and southerly. The bars are of the compact ferruginous type common to this district, and as usual are frequently broken by faults, rich chutes of gold being generally obtained at the spots where these breaks occur. Good water was struck at 135ft. The total stone crushed from this lease to date is 1,007 tons for 844·35ozs., including 55ozs. dollied and specimens; giving an average of ·83oz. per ton.

Hesperian and Lady Bunbury G.M.Ls. 361M, 379M.—These two leases are at present being worked in conjunction; a main pumping and hauling shaft has been sunk to a depth of 200ft. on the Lady Bunbury lease, near the northern boundary; a large quantity of water is being pumped out of this shaft, thus draining

both this property and the adjoining one (the Hesperian). On this latter lease a vertical shaft has been sunk to a depth of 100ft. near the southern boundary, for the purpose of working a rich body of ore occurring in a break in a large quartzite bar which runs north-westerly and south-easterly through the middle of the two properties. This ore body is some 30 feet in length (being entirely confined within the limits of the quartzite bar), and varies in thickness from about 12 feet to almost nothing; it consists of brecciated quartzite cemented together with chalcedonic quartz and small quartz veins. It has no well-defined walls, passing in places gradually into the hard compact quartzite of the bar, which, as usual, carries only a slight trace of gold. It dips at an angle of about 80 degrees to the south-east, and at about the 150-feet level passes into the Lady Bunbury lease. From the Hesperian shaft a short drive has been put in at the 100-feet level, and a winze sunk to 150 feet. The whole ore body has then been stoped out to the surface. From the 150-feet level a second winze has been put down another 50 feet, and connected by a short drive with the Lady Bunbury shaft, and stoping is now (November, 1902) being carried up from this level, where the average width of the ore body is from one to two feet. The gold contents of the stone raised vary considerably; some of the richest ore was got from the 150-feet level, where some parcels of stone were got averaging about 30ozs. Samples from the 125-feet level, Hesperian G.M., assayed in the departmental laboratory gave results ranging from 2ozs. to $11\frac{1}{2}$ozs. per ton. A large number of parallel quartzite bars run through these two properties, and shafts have been sunk on several of them, but without satisfactory results. The country is soft decomposed greenstone, passing into hard settled rock at about 180 feet. Like most of the mines in this district, the water is fresh, and was first met with at 150 feet. The crushings from these two properties to the end of 1902 were as follows:—

—	Stone crushed.	Gold therefrom.	Average oz. per ton.
	tons.	ozs.	
Hesperian	1,597·00	2,134·50	1·33
Lady Bunbury ...	512·65	166·84	0·32

Eclipse Extended G.M.L. 264m.—On this lease a vertical shaft has been sunk to a depth of about 110 feet on an ore body exactly similar in character and mode of occurrence to that on the Hesperian lease. This ore body extends only the width of the quartzite bar in which it is found, about 30 feet, and varies in thickness from three to 20 feet. It has been stoped out for its full width from 110 feet to the surface, but no further work has been done on it. Total stone crushed, 914·75 tons for 1,830·59ozs., being at the rate of 2·00ozs. per ton.

Hesperus Dawn G.M.L. 463.—An ore body similar in all respects to the two foregoing has been worked out on this property to a depth of 150 feet (water level). At the time of my visit no work was being done, owing to the property being under exemption. From this lease, 521·98 tons of stone have been crushed for a yield of 1,860·95ozs., being at the rate of 3·56ozs. per ton.

Golden Belle G.M.L. 648.—There are several small shafts on this property working on small bodies of ore in the breaks of the quartzite bars similar to those worked in the three previous properties. There have been no crushings from this property to date.

Jupiter G.M.L. 190.—Four small quartzite bars run through this lease, in a north-westerly and south-easterly direction. On the most easterly of these a main shaft has been sunk to a depth of 175 feet, and levels driven along the bar at 100 and 175 feet; that at 100 feet has been driven some 100 feet northerly and 200 feet southerly, and that at 175 feet about 50 feet northerly and 170 feet southerly. At present the lower workings are flooded, and the mine full of water to 105 feet. A small party are now working the property on tribute, and are engaged in taking out stone from the 100-feet level. The bar as opened up here is from 4 to 6 feet wide, and carries gold right through in amounts varying from several dwts. to as much as 2ozs. For the most part it consists of hard compact ferruginous quartzite, but some parts are considerably softer and less compact than others. It is in these softer portions that the best gold is found. Several faults cross the bars in an east and west direction, and rich chutes of stone are generally found along the breaks. Below water level the stone carries a large amount of pyrites, which is invariably found to carry gold. Several smaller shafts have been sunk on the main bar, and also on a second small bar further westward, but very little work has been done from them. A small felsite dyke runs across the lease in an east and west direction, about 150 feet south of the main shafts, and cuts through the bars, without, however, displacing them at all. The country to water level consists of soft decomposed greenstone, becoming harder and more settled at about 150 to 180 feet. Salt water was struck at 110 feet, and was very abundant at the lower levels. This is the only mine in the Boogardie district in which salt water has been met with. From this lease 1,630·15 tons of stone have been crushed, for a total yield of 1,252·08ozs., giving an average of ·77oz. per ton.

Sirdar G.M.L. 571.—There are two vertical shafts down on this lease, one, the main working shaft, down 90 feet, and the other 55 feet. The main shaft has been sunk on the west side of a large north-west and south-east quartzite bar, and at 75 feet a crosscut has been driven easterly into the bar for a distance of about 60 feet. The bar for the whole of this distance carries gold, and averages from 6 to 12dwts. No stoping has been done, and no drives put in at the lower level. From the second shaft two crosscuts have been put in, one at the 40 feet level for about 20 feet easterly, and one at the 55 feet for some 45 feet westerly. This latter crosscut

cuts through three small vertical quartzite bars, running north-west and south-east, the first two of which are about three feet wide, and the third almost westerly about 20 feet. These bars have been sampled for their full width, their average gold contents being about 8dwts. per ton. In all 529 tons of stone have been crushed from this mine for a yield of 244·30ozs., being at the rate of ·46oz. per ton.

Neptune G.M.L. 445.—The main working shaft on this property has been sunk vertically to a depth of 210 feet on the eastern side of a large quartzite bar running through the middle of the lease in the prevailing north-west and south-east direction. Two drives have been put in south-westerly from it, one at 109 feet and the other at 200 feet, both of which are about 70 feet in length. The ore body consists of quartzite and brecciated quartzite, and is some three or four feet wide; it runs vertically across the main quartzite bar in a south-westerly direction, and is apparently an old fault line along which the quartz has been deposited. The length of the ore body has not yet been proved. The gold contents, as is usual with this class of ore body in this district, vary considerably, ranging from 1oz. to 13ozs., being richest where the quartz is most abundant. The main body of quartzite also carries a considerable amount of gold, but not sufficient to pay for working. The country on each side of the quartzite bar consists of greenstone, very decomposed and softened near the surface, but becoming hard and compact at the 200-feet level. Several small shafts have been put down at different places along the main bar of quartzite, but without result, and have since been abandoned. A good supply of fresh water was struck in the main shaft at about 110 feet. The total crushings to date from this mine are 452 tons for 1,161·15ozs., including 557·76ozs. dollied and specimens, being an average of 2·57ozs. per ton.

Marsite G.M.L. 220 (late O.K. North).—On this property a quartz reef running north-east and south-west has been worked by means of three shafts, two vertical and one underlay, down to depths varying from 50 to 80 feet. At present two of these shafts have been abandoned, and the reef is being worked from a main vertical shaft, sunk on it to a depth of 80ft. At this level drives have been put in both ways along the reef for a total distance of about 200 feet, and a winze sunk a further depth of 35 feet to water level. No stoping has been done. The reef consists of white quartz considerably laminated at the northern end, and is about four feet wide. It runs vertically, and has sharp, well-defined walls on both sides, the country being soft, decomposed greenstone. The average gold contents of the reef are about 6dwts. per ton. A fourth shaft has been sunk on a small quartzite bar near the southern boundary of the property, but without any satisfactory results, and it has since been abandoned. The returns from this mine to date are 24 tons of stone crushed for a yield of 5·50ozs., being at the rate of ·23oz. per ton.

LENNONVILLE.

Golden Giant West G.M.L. 567.—There is a main vertical shaft down some 150 feet on this lease. It is, however, at present (October, 1902) abandoned, and the only work done on the property is being carried on in a large open cut. The lode, as opened up in this cut, consists of banded quartzite intersected by numerous small quartz leaders. The full width of it has not yet been exposed. Some samples of stone taken from the face of the open cut and dollied, gave very good prospects.

Baxter's Reward G.M.L. 604m.—On this property a main shaft has been sunk vertically to a depth of 135ft. in the centre of a large quartzite bar. At 75ft. a drive has been put in north and south along the strike of the quartzites with the object of working a small quartz reef running in that direction. This reef at the southern end of the drive is about 1ft. in width and about 2ft. 6in. at the northern end and dips at a high angle to the westward. Drives have also been put in both ways along the reef at 95ft. and 135ft. for about the same distance, the reef being of the same size as in the upper level; a crosscut has also been put in Easterly for a distance of some 20ft. at the 135ft. level in order to test the values of the quartzites, which always carry a certain amount of gold.

Fair Play G.M.L. 333m.—On this lease two vertical shafts have been sunk (some 160ft. apart) on a small north and south quartz reef. Of these the main shaft has been sunk to a depth of 200ft. while the second, or more Northerly, is down 130ft. to water level. These shafts are connected at the 130-feet level by a drive which has also been continued some 60ft. south of the main shaft; at the 200-feet level about 90ft. of driving has been done from the main shaft some 70ft. north and 20ft. south; a winze has also been sunk from the 130-feet level to a further depth of 35ft. at a point some 30ft. south of the northern shaft. The reef consists of white quartz and is small, having a maximum thickness of some 10in. to 13in. The country is soft decomposed greenstone.

Simmer and Jack G.M.L. 586.—A small vertical North and South quartz reef is being worked on this property; several shafts have been sunk, the main one being down 105ft. vertical, and a fair amount of work done. The reef is very thin as a rule, but at one place there is a thickness of nearly five feet of clean quartz. Another vertical shaft further west is down about 100ft., and a crosscut has been put in Easterly for a distance of some 50ft. at the 40-feet level. The shaft has, however, been since abandoned. The country consists of a slightly decomposed foliated serpentinous rock, the lines of cleavage of which trend north and south, and run vertically.

Splendour G.M.L. 421m.—A fair sized North and South reef runs through the centre of this lease, dipping at a high angle to the

westward. A vertical shaft has been sunk to a depth of 80ft. on the footwall side, and short crosscuts have been put in to cut the reef at 50ft. and 80ft., and levels driven along it for some distance. The average width of the reef is about two feet six inches, but it is rather irregular, being as much as five feet in width in some places.

Tarcoola G.M.L. 590m.—There are several shafts down on this property to depths varying from 40 to 70 feet; the main working shaft is down 70ft., on a fair sized quartz reef, trending north-west and south-east and dipping to the westward. This reef is from four to five feet wide, and a considerable amount of work has been done on it, but at present (October, 1902), the workings are inaccessible. Another working shaft, further to the north-east, is down some 70ft. on a small quartz reef, striking north-west and dipping to the westward. The width of this reef is about 18 inches.

Gambier 535m.—On this lease a main shaft has been sunk to a depth of 140ft. on the western side of a quartz reef, striking north-west and south-east, and at 60ft. a crosscut has been put in easterly to cut the reef, and a level driven along the line of the reef. This reef is some three feet wide, and is, apparently, the same one as is being worked on the adjoining lease (the Tarcoola). The lower workings on the property were inaccessible.

The Giant G.M.L.—This property adjoins the Canterbury on the south. Very little work has been done on it. At present there is a large open cut on a banded quartzite bar. A small quartz reef runs through the deposit in the direction of the strike of the quartzite (north and south). Samples taken from the open cut and dollied showed good prospects. 65·00 tons have been crushed from the lease for a yield of 18·53ozs., being at the rate of ·28oz. per ton.

Brooklyn South G.M.L. 605.—Here a shaft has been sunk to a depth of about 80ft. on a vertical quartz reef running north and south. A drive has been put in 40ft. along the reef southerly at the 50-feet level, and a little stoping has been done.

Union Jack G.M.L. 611.—A large banded quartzite bar runs north and south through the centre of this property. On the western side of this bar an underlay shaft has been sunk to a depth of about 30ft. The section in the shaft shows the lode to consist of banded grey and white quartz, with bands of kaolin, rendering the deposit very friable. No further work has been done, and the full width of the deposit is not yet determined. There have been no crushings to date.

Golden Hill G.M.L. 511.—This property is also working on a large north and south body of banded quartzites. The main body of these is some three to four chains across, and runs through the middle of the property. On the western side of this body a shaft has been sunk to a vertical depth of 80ft., and a drive put in northerly for a distance of 35ft. at this level. The ore body is situated on the extreme western edge of the quartzite bar, and is from five to eight feet in width. It consists of a brecciated mass of quartzite cemented together with kaolin, and varies considerably in its gold contents. This property has crushed to the end of 1902 298·50 tons for 85·07ozs., giving an average of ·27oz. per ton.

The Farm G.M.L., 582.—This property adjoins the Golden Gem on the south; on it a main shaft has been sunk about 50ft., and crosscuts put in north-west and south-east for a total distance of about 200ft., but so far without result. The country consists of very soft decomposed greenstone.

Galtee More G.M.L. 343.—This property is situated some three miles south of Lennonville townsite. A large banded quartzite lode runs through the lease in a general north and south direction. This lode, the full width of which has not yet been determined, is being worked by means of four shafts, the deepest of which has been sunk to a vertical depth of 120 feet. On the north end of the lease a shaft has been sunk vertically for 100 feet, and a short level put in at 40 feet, and a somewhat longer one at 80 feet; this level has been driven about 40 feet north and the same distance south, and a crosscut has been put in westerly from it for a distance of about 90 feet; no stoping has been done. Of the three shafts at the southern end of the lease, the deepest is 120 feet and the other two 60 feet and 105 feet, respectively; from the latter of these, drives have been put in north and south at the 40, 60, 80, and 100 feet levels for about 100 to 120 feet each way, and a considerable amount of crosscutting and stoping has been done, the three shafts being connected at the lower levels.

The two largest gold producers in the Lennonville district are the Long Reef G.M. and the Wheel of Fortune North. These have respectively produced, to the end of 1902, 37,911·19ozs. from 54,766·25 tons, and 9,296·14ozs. from 3,123·00 tons.

The following tables, compiled from the latest official information, show the gold returns from the various leases in the district, other than those already mentioned, up to the end of 1902. It may be mentioned, however, that the majority of the leases named in

these lists have been abandoned for some years past, very little work having been done upon them :—

OUTPUT OF GOLD BY DISTRICTS.

Lennonville District.

Name of Lease.	No. of Lease.	Total Gold Yield to end of 1902. Ore Milled.	Gold Yield.	Average ozs. per ton.
		tons.	ozs.	
Agnes	302M	13·00	4·15	·32
Ardpatrick	613M	322·00	265·50	·82
Bushman	644M	19·00	13·00	·69
British Exploration Co., Ltd.	78, 74M	110·00	144·65	1·31
Briton	602M	28·00	6·63	·24
Canterbury	519M	301·00	392·58	1·34
Canterbury Extended No. 1 ...	459M	12·00	1·10	·09
Colonial Consolidated Finance Corporation Co., Ltd. late Corsaire Consolidated G.M. Co.	80M, R.C., 2M; 80M, 345M	4,934·00	3,013·02	·63
Federal	407M	10·00	·55	·05
Geraldton United	144M	51·00	13·13	·26
Golden Gem	201M	550·50	1,371·79	2·49
Golden Giant Leases	47M, 179M	147·00	71·40	·49
Grand Gorge	549M	456·50	982·30	2·13
Haeremai	628M	54·00	90·25	1·67
Helm	494M	20·00	16·85	·84
Josephine	453M	6·00	·91	·15
Kathleen	559M	5·00	6·50	1·30
Keep-it-dark	393M	49·90	103·10	2·07
Klondyke	348M	36·00	*142·91	3·94
Lady Brassey	379M	97·00	203·35	2·10
Last Chance United	556M	54·00	17·07	·31
Lady of the Lake	486M	14·00	8·10	·57
Long Reef Central	542M	190·00	83·29	·44
Matterhorn	632M	12·00	3·80	·31
Magnet Gem	322M	22·00	14·18	·64
Merriwee	606M	22·00	37·37	1·70
Mabel	578M	118·00	28·35	·24
Mount Blanc	539M	14·00	3·00	·21
Murchison Boulder	425M	26·00	7·47	·28
Queenslander	552M	395·50	210·69	·53
Queenslander South	393M	1,135·00	967·40	·85
Rock of Ages	517M	181·00	141·44	·77
Rosella	412M	13·00	14·00	1·08
Royal Surprise	278M	36·00	9·72	·27
Scottish and Colonial	449M	10·00	2·00	·20
St. Albans	359M	45·00	56·20	1·25
St. Albans South	384M	105·00	90·80	·86
Victoria	480M	39·00	11·75	·30
Vicquery Piedmont	80M	2,061·00	1,408·00	·68
Viking	431M	20·75	25·57	1·23

* Includes 29·65ozs. dollied and specimens.

Lennonville District—*continued.*

Name of Lease.	No. of Lease.	Total Gold Yield to end of 1902. Ore Milled.	Gold Yield.	Average ozs. per ton.
		Tons.	ozs.	
Wah Wah	420M	192·00	243·62	1·27
Waringee	341M	127·00	238·33*	1·87
Welcome News	395M	31·00	6·85	·22
Wheel of Fortune North ...	103M	3,123·00	9,296·14	2·91
Wheel of Fortune South Block	151M	926·65	3,401·25	3·64
Wheel of Fortune North, Extd.	109M	117·00	108·77	·92
Wrayfield	334M	114·75	133·00	1·16
Yuletide	198M	66·00	48·93	·74
Yuletide North	23M	334·00	205·44	·61

* Includes 3·35ozs. dollied and specimens.

Mount Magnet District.

Birthday...	317M	184·50	30·92	·16
Black Diamond	304M	39·00	33·95	·87
Chums Consolidated, Ltd. ...	7M, 206M, 257M, 301M, 313M, 315/6M, 324M, 555/6M	11,984·00	28,503·15	2·38
Easter Gem	543M	33·00	20·73	·63
Evening Star	389M	30·00	5·25	·17
Gascoyne (Murchison) Goldfields Exploration Co., Ltd.	49M, 56M	19·25	4·37	·23
Gay Parisienne	417M	534·85	160·21	·29
Golden Age	301M	77·00	109·65	1·42
Hector Hill	257M	24·00	7·55	·31
Homeward Bound	401M	76·50	148·16	1·94
Kapai	562M	61·00	32·99	·54
La Perola	370M	41·00	36·85	·90
Mayflower G.M., Ltd.	9M	174·00	287·98	1·65
Mt. Magnet G.Ms., Ltd. ...	64M, 319M, 399M	2,759·00	2,261·68	·82
Murchison	448M (9M)	588·00	559·29	·95
New Chum South Extd. ...	26M	163·00	28·70	·11
New Moon	371M	286·00	187·20	·65
Old Jock	560M	12·00	12·85	1·07
Pearl of Ben Rose	45M	66·00	33·25	·50
Primrose...	339M (32M)	135·00	88·95	·66
Pearl North	623M	13·00	20·00	1·54
Revenue	572M (565M)	182·00	65·00	·36
South Pearl	2M	11·00	12·45	1·13
Tarquin	63M	50·00	25·00	·50
Waikawa	565M	44·00	34·15	·77
Western Syndicate, Ltd. ...	120M, 339M	876·00	* 1,436·92	1·64
White Rose No. 1 North ...	29M	51·00	5·65	·11
L.C. 87	L.C. 87	28·00	13·25	·47

* Includes 6·04ozs. dollied and specimens.

Boogardie District.

Name of Lease.	No. of Lease.	Total Gold Yield to end of 1902. Ore Milled.	Gold Yield.	Average ozs. per ton.
		tons.	ozs.	
Bobbie Burns	462M	19·00	6·25	·32
Bobs	594M	65·00	64·25	·99
Bonanza	184M	40·00	20·00	·50
Boogardie	351M	16·00	4·52	·28
Briars	553M	12·00	21·60	1·80
Bronzewing	507M		47·75ozs. dollied and specimens.	
Constellation	337M	20·00	6·50	·32
Deep Alluvial Claim	A.C. 1	2,392·00	959·84	·40
Eclipse	172M	400·00	*826·25	2·05
Eclipse North	411M	104·00	23·76	·22
Emily Bennett	530M	15·00	3·40	·22
Exchange Leases	185M, 281M	159·00	145·05	·91
Federal	520M	14·00	†7·65	·55
Federation	410M	12·50	‡113·65	9·09
General Roberts	500M	74·00	51·70	·70
Golden Crown	173M	121·00	232·90	1·92
Golden Point	224M		7·60ozs. dollied and specimens.	
Grosotto	438M	110·50	163·60	1·49
Havelock Extended	335M	93·00	47·35	·51
Havelock Proprietary	328M	42·00	§118·34	2·82
Hesperus...	491M	6·00	6·12	1·02
Jupiter West	504M	53·00	29·05	·54
Iron Dyke	635M	6·50	‖5·63	·87
Lone Hand	435M	25·00	5·20	·20
Lucknow	226M	610·00	766·17	1·25
Magdala	518M	28·00	9·25	·33
Meteor	148M	51·00	51·70	1·01
Midlothian	182M	12·00	11·10	·92
Mystery	456M	66·50	26·13	·39
National	347M	11·00	5·15	·47
New Year's Gift	292M	20·00	20·60	1·03
Nil Desperandum	391M	57·00	40·60	·71
O.K.	160M	55·30	¶188·30	3·40
Pick-me-up	513M		8·62ozs. dollied and specimens.	
Planet	65M	247·00	149·25	·60
Rock of Cashel	307M	24·00	8·55	·35
Rose, Shamrock, and Thistle ...	426M	90·00	20·75	·23
Saturn	538M	98·00	37·85	·38
Star of the West	455M	238·00	380·70	1·60
Sun	555M	17·00	3·10	·18
Three Star	332M	106·50	**630·03	5·91
Venus	479M	279·00	1,527·48	5·48
Waverley	470M	200·00	83·85	·42
Wellington	353M	18·00	28·10	1·56
Western	469M	60·00	23·15	·38
Q.C. 77	Q.C. 77	43·00	2·12	·49

* Includes 4·80ozs. dollied and specimens. † Includes 2·70ozs. dollied and specimens. ‡ Includes 73·05ozs. dollied and specimens. § Includes 45·15ozs. dollied and specimens. ‖ Includes 2ozs. dollied. ¶ Includes 38ozs. dollied and specimens. ** Includes 61ozs. dollied and specimens.

OUTPUT OF GOLD BY LINES OF REEF.

Name of Lease.	No. of Lease.	Total Gold Yield to end of 1902. Ore milled.	Gold Yield.	Average ozs. per ton.
Empress Reef.				
		tons.	ozs.	
Empress } Empress Leases	465M	1,335·00	2,724·61	2·04
Empress North } Empress Leases	583M			
Empress South } Empress Leases	503M			
Empress Extd. } Empress Leases	544M			
Total	...	**1,335·00**	**2,724·61**	**2·04**
Brooklyn Reef.				
Brooklyn	573M	80·00	201·25	2·51
Brooklyn North...	591M			
Brooklyn Block...	610M			
Brooklyn South...	605M			
Total	...	**80·00**	**201·25**	**2·51**
Galtee More Reef.				
Galtee More	343M	3,087·00	1,847·74	·59
Galtee More North	581M			
Galtee More South	505M			
Total	...	**3,087·00**	**1,847·74**	**·59**
Simmer and Jack Reef.				
Simmer and Jack	586M	150·00	64·89	·43
Day Spring	593M	41·50	45·35	1·09
Day Spring North	597M	...	...	...
Splendour	421M	518·25	499·32	·96
Mermaid	557M	187·50	229·58	1·22
Total	...	**897·25**	**839·14**	**·93**
Gambier Reef.				
Tarcoola	590M	54·00	38·15	·70
Gambier	535M	125·50	124·20	·99
Gambier Extd.	554M	...	...	...
Total	...	**179·50**	**162·35**	**·90**

Name of Lease.	No. of Lease.	Total Gold Yield to end of 1902. Ore Milled.	Gold Yield.	Average ozs. per ton.
Long Reef Reef.				
		tons.	ozs.	
Long Reef	30M	54,766·25	37,911·19	·69
Long Reef North	31M	153·00	206·80	1·35
Long Reef South	433M	...	...	...
Total	...	**54,919·25**	**38,117·99**	**·69**
Burra Burra Line of Reef.				
Last Chance	541M	54·00	20·55	·38
Burra Burra	327M	} 1,133·50	3,468·95	3·06
Burra Burra Extended ...	346M			
Burra Burra South Extended	368M			
Total	...	**1,187·50**	**3,489·50**	**2·93**
Lennonville Line of Reef.				
Brilliant	48M	52·700	564·15	1·07
Lennonville	512M	395·00	824·80	2·09
Moonstone North	595M	} 10·00	3·50	·35
Moonstone South	601M			
Total	...	**932·00**	**1,392·45**	**1·49**
Welcome Reef.				
Golden Giant West	143M	80·00	68·85	·86
Sullivan's Dunlop	405M	609·00	584·65	·96
Welcome	57M	1,860·00	*6,259·19	3·36
Baxter's Reward	604M	139·00	26·55	·19
Total	...	**2,688·00**	**6,939·24**	**2·58**

* Includes 2,550·00ozs. dollied and specimens.

Name of Lease.	No. of Lease.	Ore Milled.	Gold Yield.	Average ozs. per ton.
Fair Play Reef.				
Occidental Extended	508M	57·50	100·65	1·75
Golden Treasure Leases, G.O.M.	41M, 508M, 52M	1,433·00	984·36	·69
Fair Play	333M	411·00	773·02	1·88
Speedwell	436M	21·00	35·65	1·70
Occidental Leases	66M	87·80	156·92	1·78
Total	...	**2,010·30**	**2,040·60**	**1·01**

Source of Ore.	Total Yield to end of 1902.		
	Ore Milled.	Gold Yield.	Average ozs. per ton.

Miscellaneous Returns.

	tons.	ozs.	
Sundry claims at Boogardie	1,450·50	* 688·72	·47
Do. do. Mt. Magnet	1,944·60	†2,549·02	1·31
Do. do. Lennonville	593·25	‡ 472·22	·79

From district generally—	ozs.
Sundry parcels treated at Australian Gold Recovery Works	5,009·40
" " " New Chum Works	1,382·75
" " " State Battery, Lennonville ...	2,859·37
Alluvial	613·83

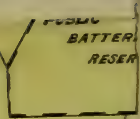
* Includes 5·86ozs. dollied and specimens.
† " 23·07ozs. " "
‡ " 13·50ozs. " "

Total gold yield from district embraced within the limits of the area referred to in this report up to end of 1902 is synoptically shown in the following table:—

	Alluvial.	Tons Crushed.	Gold Yield.	Average ozs. per ton.
	ozs.		ozs.	
Boogardie	...	15,800·83	* 18,536·50	1·17
Mt. Magnet	...	91,940·20	† 82,958·11	·90
Lennonville	...	84,079·10	‡ 80,811·80	·96
District generally ...	613·83	—	9,251·52	—
Total	**613·83**	**191,820·13**	**191,517·93**	**·99**

* Includes 1,052·13ozs. dollied and specimens.
† " 29·11ozs. " "
‡ " 2,642·48ozs. " "

By Authority: Wm. Alfred Watson, Government Printer, Perth.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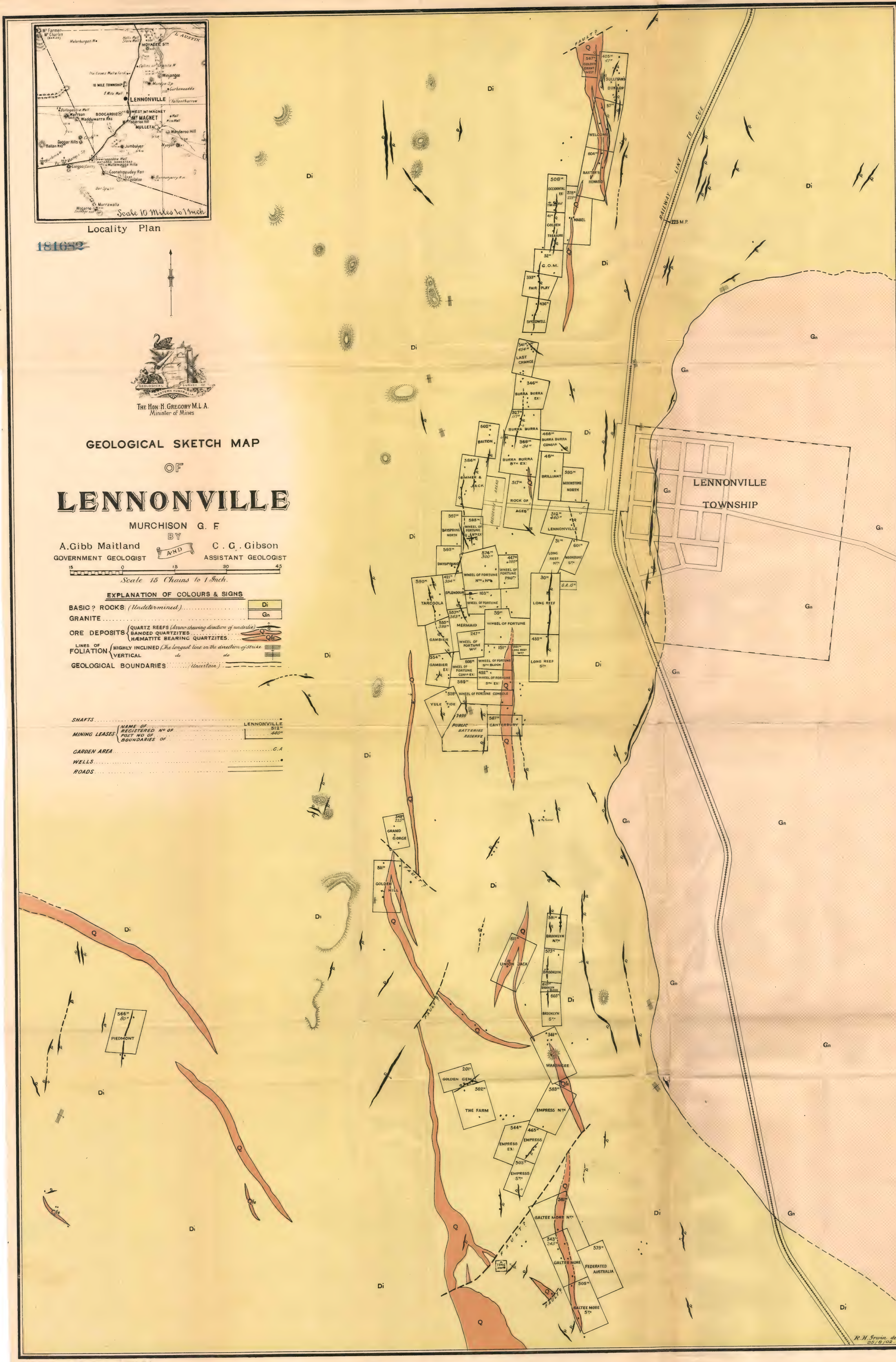

H. J. Pether, Government Photolithographer, Perth, W.A.


BOOGARDIE
TOWNSHIP
Mt MAGNET
Mt MAGNET
TOWNSHIP
Residence Area Res.
Explosives Res.
Hospital Res.
Recreation Res.
Camping Res.
FROM MULLEWA
LOCALITY PLAN
Scale of Miles
Hon: H. Gregory M.L.A.
Minister for Mines
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
GEOLOGICAL SKETCH MAP
OF
BOOGARDIE And Mt MAGNET
MURCHISON G. F.
BY
C. G. Gibson
ASSISTANT GEOLOGIST
1903
EXPLANATION of COLOURS & SIGNS
DRY BLOWN PATCHES
GREENSTONE (DIORITE, DIABASE, PYROXENITE &c) Di
GRANITE Gn
ORE DEPOSITS (QUARTZ REEFS (Arrow shewing direction of underlie), BANDED QUARTZITES, HÆMATITE BEARING QUARTZITES)
LINES OF FOLIATION (The longest line in the direction of Strike)
FAULTS
GEOLOGICAL BOUNDARIES
SHAFTS
MINING LEASES (NAME OF, REGISTERED No OF, POST No OF, BOUNDARIES OF, VOID) VENUS 479 127
GARDEN AREA G.A.
AGRICULTURAL AREA A.A.
RESIDENCE AREA R.A.
TAILINGS AREA T.A.
REEF CLAIM R.C.
LODE CLAIM L.C.
WATER RIGHT W.R.
WELLS
ROADS
A Gibb Maitland
Government Geologist
R.H. Irwin del: 21/7/03
181682

1903.

WESTERN AUSTRALIA.

GEOLOGICAL SURVEY.

BULLETIN No. 9.

THE

Geological Features and Mineral Resources of Northampton,

BY

A. GIBB MAITLAND,
Government Geologist,

WITH

APPENDICES

BY

H. P. WOODWARD, JOHN PROVIS, and E. S. SIMPSON.

Issued under the authority of the Hon. H. Gregory, M.L.A., Minister for Mines.

WITH A MAP AND SECTIONS.

PERTH:
BY AUTHORITY: WM. ALFRED WATSON, GOVERNMENT PRINTER.

1903.

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PLATE.

MAP.

PREFATORY NOTE.

CONSIDERABLE attention having been directed to the resources of the Northampton District, the Hon. the Minister for Mines determined upon the publication of the Departmental Reports presented to the Government from time to time, but which, up to the present, have never been issued in such a form as would render them readily accessible to the general public.

A. GIBB MAITLAND,

Government Geologist.

Geological Survey Office,

Beaufort Street,

Perth, 1st July, 1903.

THE GEOLOGICAL FEATURES

AND

MINERAL RESOURCES OF NORTHAMPTON.

The month of January, 1897, found me at Northampton, engaged upon an examination of the geological features of the lead and copper mining district.

The ground, which was examined and mapped in some detail, embraces an area of about 100 square miles, and is depicted on the accompanying map, which has been photographically reduced from the large scale Geological Map of the district.

Mining in the early days was carried out in the most parsimonious manner, and sinking was discontinued when the lodes showed signs of contracting—a condition, however, to which all such deposits are subject. This circumstance, coupled with the low price of both lead and copper, would appear to have been the reason which led to the suspension of mining operations.

Mr. F. T. Gregory, writing * in the year 1861, would seem to have been the first to describe the occurrence of the lodes of lead and copper, in the following words:—

> "These lodes take an almost invariable direction of N. 32° E., with a general dip of about 80° to the W.N.W., and are accompanied by parallel dykes of whinstone, quartz, or porphyry, varying from a few feet to 50 or 60 yards in breadth."

In the year 1871 Mr. H. Y. L. Brown, at that time Government Geologist, examined the neighbourhood, and in his report † gave a description of such of the properties as were then accessible. This report, and the accompanying small scale map, is long since out of print. Mr. Brown, who had far better opportunities of examining the mines than any of his successors, wrote in no uncertain terms as to the district affording a wide field for the profitable employment of capital.

The report of Mr. Brown was followed in 1888 by that of Mr. H. P. Woodward, who noted the difficulty he experienced in examining any of the mines, which were either full of water or

* On the Geology of a part of Western Australia.—Q.J.G.S.: London, 1861: Vol. xvii., p. 478. † Geological and Mining Report on the Champion Bay Mining District, Western Australia. Perth: By Authority, 1871.

otherwise inaccessible. By far the best description of the copper and lead mines of the district is that from the pen of this author in 1895.*

My own visit added nothing to our knowledge of the underground workings, which were even in a worse condition than when visited by my predecessors, and were absolutely inaccessible.

During the course of the examination of the district, I was forcibly impressed with the association described by Gregory † of the lodes with the basic dykes which traverse the country for considerable distances with a remarkably persistent trend. The dykes being of commercial importance, owing to their intimate connection with the deposition of metalliferous minerals, it seemed to me that the greatest assistance the geological survey could render to private enterprise in the district would be in the direction of accurately mapping these igneous rocks, and by so doing afford a reliable guide as to the horizontal extent of the ore bodies, and possibly lead to the discovery of others.

Owing, however, to the absence of a topographical map on a sufficiently large scale, upon which the geological features could be shown in sufficient detail, the geological survey had to be delayed until this had been accomplished. The topographer completed this work by the end of June, but it was not until the month of September that I was able to proceed to Northampton to put in the geological details.

The district under examination occupies an elevated tract of country, drained by the tributaries of the Bowes River, which all take their rise in the rugged hills forming the most northerly portion of the district under examination.

The banks of the more important watercourses, Udandarra Creek and Nokenena Brook, are skirted by a width, more or less great, of recent superficial deposits: these have been shown upon the map. It is worthy of note that Mr. F. T. Gregory, writing in 1861,† notes the discovery by some member of his party of gold in these alluvial deposits in the Bowes River.

A series of sandstones and conglomerates once covered the whole surface of the ground, and now the only remnant left consists of an extensive tableland, whose extent is marked by a bold precipitous escarpment of several miles in length on the Eastern portion of the district. A similar tableland occupies the north-western corner in the vicinity of Weeine Well and Appedagena Peaks, whilst the series is represented on the south by a narrow bed, due south of Loc. 2190, drained by the southern waters of Nokenena Brook. Some of the sandstone beds are quasi-vitreous.

In one portion of the district is a comparatively thin bed of very ferruginous conglomerate, which contains a fairly large proportion of clayey matter. In its characteristic mode of weathering, the rock differs materially from that of the sedimentary beds beneath.‡

* Copper and Lead Mines of the Victoria District, *vide* Mining Handbook to the Colony of Western Australia, Perth: By Authority, 1895. 2nd Edition, pp. 117-126.
† Loc. Cit. ‡ This bed is in reality a residual conglomerate, to which the term laterite has been officially applied in the case of similar deposits in other portions of the State.

One section shows the conglomerate passing down insensibly into the underlying rocks. The ferruginous conglomerate is not, strictly speaking, horizontal, but seems to have adapted itself to the shape of the ground, forming as it were a thin covering, now partially denuded, which extended over the whole surface.

In a traverse from Northampton to the mouth of the Bowes River, these sedimentary beds are seen to consist of grits and flagstones, dipping at a low angle to the west, and are covered by the much newer beds of the Coastal Limestone Series. There is no evidence as to the geological age of the grits, flagstones, and conglomerates; they are, however, coterminous with those which form what is shown on all the maps as Moresby's Flat-topped Range to the south.

From beneath these sedimentary beds emerge those granites, gneisses, mica schists, quartz schists, etc., intersected by veins and masses of pegmatite, which, from an economic point of view, form by far the most important feature in the structural geology of the district, and cover the largest area of ground. It has been found quite impossible to draw any line separating each of these rocks, hence all have been delineated on the map by the same colour and symbol. In the absence of chemical analysis and microscopic examination, no further details can be given regarding these rocks.

The summit of a bare hill east of Brookside Farm is interesting, as showing a sheeted zone of micaceous and garnetiferous schist. The rock is traversed by bands of quartz, often much contorted and puckered, and stands out in such bold relief as to be readily followed by the eye across country. The general trend of these sheeted zones, as can be seen by an inspection of the map, is generally north-west and south-east. Another similar parallel sheeted zone of garnetiferous gneiss occupies the country to the north-east of the Baddera Mining Lease 1472, and an identical band makes its appearance to the south-east of Reserve 1374, at the foot of the sandstone tableland at the head waters of the Bowes River. What appears to be a continuation of this band is again visible on the surface in what is known as Poison Well.

A remarkably persistent band of quartz schist can be traced from the Two-mile Hill, just to the south of the limits of the map. The schist, which forms a bold topographical feature, forms a horseshoe-shaped curve, passing through the Two-mile Hill and Trig. Station No. 18, and for some considerable distance further, occupying in all a distance of about three miles. The quartz schist has a steep dip to the East. *

In the bed of the Bowes River, just above the station, is a bed of very coarse pegmatite intersecting the gneiss; the pegmatite is about 10 to 12 feet in thickness, and has a general trend to the northwards. In portions of the pegmatite there appear to be bands of gneiss caught up in the rock mass.

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* A much wider acquaintance with the geology of the mineral-bearing districts of the State leads me to believe that this quartz schist is merely another form of those laminated quartzites (cherts ?) which form such a pronounced feature in certain districts.

The most important structural feature is the system of basic dykes with which the whole area is seamed; these extend far beyond the limits of the country examined. So far as my operations have extended, these dykes have no apparent connection with any visible deep-seated rock of similar composition. The basic rocks exhibit, when their trend is laid down upon a map with some degree of accuracy, a remarkable parallelism, having a general trend of north-east and south-west. The longest has been traced across country without interruption for a distance of over 10 miles, and extends, both north and south, far beyond the limits of the country examined. The breadth varies very much in different places, but in no case was the width exposed on the surface very great; although according to Mr. F. T. Gregory * the width of some of these examined by him reached as much as 180 feet. Wherever any sections were visible the dykes were either vertical or inclined at very high angles.

The rocks of which the dykes are composed are all basic compounds. An analysis of one of the most typical of these (200) from the vicinity of the crossing at Udandarra Creek, yielded at the hands of Mr. E. S. Simpson the following composition:—

Silica, SiO_2	53·06
Alumina, Al_2O_3	13·67
Ferric Oxide, Fe_2O_3	4·83
Ferrous Oxide, FeO	9·96
Manganese Oxide, MnO	0·56
Lime, CaO	8·62
Magnesia, MgO	5·31
Potash, K_2O	1·29
Soda, Na_2O	3·22
Loss on ignition	0·38
	100·90
Specific gravity...	3·07

This rock was found to be coarse grained, consisting almost entirely of multiply-twinned felspar and augite, together with a little magnetite.

Future Prospects.

Over the whole of the district under examination there is not a mine which has been sunk to a greater depth than 300ft., and operations ceased when the lodes showed signs of cutting out.

From an examination of the geological map of the district it can be seen that the area is traversed by a series of basic dykes which are continuous for miles, and that parallel to these are those lodes of lead and copper which have already been opened up in one or two localities. Igneous dykes of this nature represent what were originally fractures in the earth's crust, which pass downwards to very considerable depths, and the copper and lead lodes fill in fissures of a similar character, which find their origin far below the limit of practical mining. The lodes in consequence will continue downwards as far as ever operations are likely to be carried.

The method of the formation of fractures, and the movement of either of the walls, have the effect of producing alterations in

* Loc. Cit.

the nature of the fissures by forming wide or narrow portions, which have been subsequently filled with ore. There must always be local variations in the metallic contents of ore bodies, but there are no scientific grounds for believing that what may be called the shallow mines of the Northampton District have reached the limits of ore deposition, and that the ore bodies will not prove equally productive when followed either horizontally or vertically. As the deposition of the ore bodies is most intimately connected with the system of fracturing to which the district has been subject, it is evident that the search for further lodes must follow that direction which the evidence already accumulated has shown to be that of greatest ore deposition; and this direction is that which lies parallel to the system of basic dykes shown upon the map. A system of judicious prospecting carried out upon these lines should result in the discovery of other lodes equally productive to those already exploited.

The Output of Ore.

It appears that mining first commenced in the year 1842, and since that date 9,349·78 tons of copper and 33,643·85 tons of lead ore have been raised from the mines and exported from the district.

Unfortunately, it is impossible to give the output of the individual mines of the district, but I am under obligation to Mr. S. Mitchell, for the following returns shown in the tables appended. These, however, do not in all cases represent the actual output of ore, but are merely data of which a record has been kept; and on that account are worthy of record. These data have been compiled from the sale notes supplied to the vendors in England, where most of the ore had been sent; and the figures in the second column represent the value of shipments of copper and lead, from which it can readily be seen that ore of very different metallic percentages must have been raised.

Statement of Lead Ore raised from some of the Northampton Mines.

Name of Lease.	Date.	Quantity of Ore raised.			Total value of Ore.		
		tons	cwt.	qrs.	£	s.	d.
Baddera, No. 1	1883	40	0	1	299	6	0
Do.	1884	29	14	4	172	11	8
Baddera, No. 2	1884	14	9	0	67	5	0
Do.	1885	26	10	2	103	15	7
Do.	1886	0	8	2	2	10	11
Do.	1891	118	0	1	766	8	9
Geraldine, South	1886	6	8	0	44	17	8
Uga No. 1, South	1883	163	5	3	1,218	15	8
Do.	1884	51	19	2	277	17	10
Do.	1885	174	0	3	965	11	7
Uga No. 2, South	1883	13	6	1	80	17	7
Do.	1884	2	4	1	10	14	10
Wheal Ellen...	1883	0	4	2	1	16	4
Yiapa	1885	88	12	2	444	10	7
Baddera and South Uga	1884	143	14	0	789	1	5
Different Mines mixed	1890	74	9	1	483	8	4

Statement of Copper Ore raised from some of the Northampton Mines.

Name.	Date.	Quantity of Ore raised.	Total value of Ore.
		tons cwts. qrs.	£ s. d.
Gwalla	1863	12 3 0	260 4 8
Do.	1864	132 14 0	3,956 9 6
Do.	1865	88 11 0	1,866 16 9
Do.	1866	163 13 0	1,044 9 8
Do.	1867	172 7 0	2,976 1 1
Do.	1868	263 1 0	3,664 19 8
Do.	1869	70 18 0	904 7 1
Yanganooka	1866	292 0 0	3,725 16 7
Do.	1867	164 18 0	2,155 3 7

Appended will be found a table taken from the report of the Stati-t to the Mines Department, showing the quantity and value of copper and lead ore exported from the neighbourhood since 1850. The first shipment of ore from the district is said to have taken place during the year 1845, but no details as to either the quantity or the value are obtainable.

Table showing the Export of Copper and Lead Ore from the Northampton Mining District.

Year.	Copper Ore.		Lead Ore.	
	Quantity.	Value.	Quantity.	Value.
	tons	£	tons	£
1850	...	...	5·00	55·00
1	...	...	...	...
2	...	...	...	...
3	*	7·50	*	4·00
4	...	...	...	...
5	2·05	26·45	25·00	250·00
6	57·00	1,017·90	...	...
7	80·00	1,920·00	...	...
8	433·25	9,531·50	...	...
9	941·50	14,122·50	13·50	135·00
1860	517·50	8,021·25	98·50	985·00
1	409·00	6,339·50	79·00	790·00
2	783·50	12,536·00	9·00	90·00
3	763·00	12,208·00	230·00	2,300·00
4	1,076·00	17,216·00	80·00	800·00
5	886·00	13,290·00	703·00	8,436·00
6	557·50	8,362·50	273·50	3,282·00
7	337·00	5,055·00	902·00	10,824·00
8	83·00	1,245·00	1,100·50	13,206·00
9	155·00	2,325·00	699·50	8,394·00

* Declared weight not stated.

Table showing the Export of Copper and Lead Ore from the Northampton Mining District—continued.

Year.		Copper Ore.		Lead Ore.	
		Quantity.	Value.	Quantity.	Value.
		tons	£	tons	£
1870	... ...	6·00	90·00	1,209·50	14,514·00
1	... ...	...	...	420·00	5,040·00
2	... ...	...	...	364·00	4,368·00
3	... ...	56·50	847·50	965·50	11,586·00
4	... ...	66·50	997·50	2,143·75	25,725·00
5	... ...	204·75	3,071·25	2,289·00	27,468·00
6	... ...	279·00	4,185·00	2,191·50	26,298·00
7	... ...	53·50	802·50	3,955·50	47,466·00
8	... ...	9·00	135·00	3,617·50	43,410·00
9	... ...	...	...	2,775·00	33,300·00
1880	... ...	8·00	120·00	1,921·00	15,368·00
1	... ...	...	...	1,400·50	11,204·00
2	... ...	1·50	22·50	1,793·50	14,348·00
3	... ...	5·00	75·00	1,038·00	7,266·00
4	... ...	118·00	1,770·00	696·00	4,872·00
5	... ...	119·50	1,792·50	465·00	3,255·00
6	... ...	249·00	3,735·00	611·00	4,277·00
7	... ...	23·00	345·00	471·00	4,710·00
8	... ...	87·50	1,487·50	532·00	5,320·00
9	... ...	112·00	1,904·00	250·00	2,500·00
1890	... ...	8·00	136·00	213·50	2,135·00
1	... ...	...	...	25·00	250·00
2	... ...	155·00	2,377·20	29·75	150·00
3	... ...	...	...	...	...
4	... ...	...	...	...	...
5	... ...	24·00	120·00	...	...
6	... ...	...	...	...	...
7	... ...	21·15	302·00	*	4·00
8	... ...	†74·53	931·50	5·00	33·00
9	... ...	586·55	9,473·25	16·00	96·00
1900	... ...	...	...	26·85	242·00
1	... ...	·50	10·00	...	...
Total	...	**9,349·78**	**147,954·30**	**33,643·85**	**364,756·00**

* Declared weight not stated. † 74 tons 10cwt. 2qrs.

A. GIBB MAITLAND,

Government Geologist.

APPENDIX A.

THE NORTHAMPTON MINING DISTRICT.

Although this district has the honour of claiming that it was here that the first mine opened in the whole of Australia, at the present time so little mining is being done that Northampton, which was once a flourishing mining centre, is now little more than a deserted village.

The mines in this district are for the most part situated upon private property, the titles being acquired with all mining rights many years ago, and, therefore, it is purely optional whether the owners work them or not. The majority of these properties fell into the hands of creditors at the time when the great fall in the metal market took place; and, since the present owners have no desire to launch into mining, but continue to hold the property until a purchaser presents himself, there is no immediate prospect of a revival taking place in the near future. The remaining properties which still belong to the Crown are, for the most part, insignificant, although one or two good lodes have been worked upon them.

This year only two or three leases have been taken up, but at the present time not a single one is being worked: the only lead production being by tributers working over the old dumps.

White Peak Copper Mine.—This mine is situated upon freehold block No. 4, between the railway line and the road nine miles north of Geraldton; in it a rich bunch of ore is said to have been met with and worked, but as no work has been done since 1858, and the shaft has fallen in, no very reliable information can be obtained.

Gray's Lead Mine.—This mine is situated upon freehold block 29, which is a little over a mile to the north-east of White Peak railway station. A shaft was sunk upon this property, said to be 40 feet in depth, from which the lode was worked by means of levels, and a considerable quantity of ore is said to have been raised about 1866. The strange fact is that the manager did not seem to place any value upon carbonates, of which there are at least 20 tons still at grass. The lode is strong and well-defined, the cap being easily traced for a considerable distance north and south at the surface.

Gelirah Lead and Copper Mine.—This mine is upon freehold block No. 328, which lies close to and upon the eastern side of the railway line, about 12 miles from Geraldton. There are two parallel lodes, the most eastern of which outcrops for a distance of 300 yards, along which several shafts have been sunk to various depths of from 40 to 120 feet, from which a large quantity of copper is said to have been raised. The western lode has been traced at the surface for a distance of 200 yards, and has been

opened upon by a series of shafts. This lode was found to contain a considerable quantity of lead in places, associated with zinc blende and iron pyrites. These lodes strike north-east and south-west, and dip towards one another. A considerable quantity of both lead and copper ore is said to have been raised when this mine was worked prior to 1860, when it closed down, but was again re-opened for a short period in 1872.

Oakajee Lead Mine.—This mine is upon freehold property No. 311, which is situated upon the eastern side of the railway line, 16 miles from Geraldton. The lode, which carries a considerable quantity of pyrites mixed with the galena, strikes 20 deg. east of north, dipping at an angle of 80 deg. to 85 deg. in a south-west direction, and has been opened by two shafts 40 feet in depth. The lode, although large, is not well defined, the galena being embedded in a mass of hard quartzite and granitic rock, containing much iron pyrites. This mine, although only worked upon a small scale, is said to have produced several hundred tons of ore prior to 1870, when it was closed down.

McGuire Lead Mine.—This mine is upon freehold block 832 upon the railway line, 25 miles from Geraldton, and was owned by the Melbourne and Champion Bay Smelting Company, who had their works upon this area, but at present the chimney stack is all that remains. One shaft has been sunk to a depth of 60 feet and one 30 feet, whilst there are several small pits and trenches upon a lode which evidently contained a considerable amount of copper mixed with the lead. This now belongs to the Fremantle Smelting Company.

Kobijawanna Lead Mine.—This is situated upon Crown lands upon the western side of the railway line, about half a mile north of McGuire. It is now partly included in the Railway Reserve, and is made the main settlers camp, owing to the fact that a splendid supply of water is obtainable from one of the old shafts. The lode has been opened up by a series of small shafts and pits for a considerable distance, and shows a rich body of carbonate ore in places. This has not been worked since 1872.

Narra Tarra Copper Mine.—This mine is situated upon Freehold Nos. 118 and 119, being about 25 miles north-east from Geraldton and six miles east of the railway line. This is one of the old mines, which has not been worked since 1865, when three shafts were sunk to a depth of 20 to 25 feet, and some driving done. The lode is well defined, striking in a north-east and south-west direction, with an underlie to the north-west. From the two southern shafts copper was raised, but in the northern one galena was encountered; this at the time was thrown aside, but later on it was dressed and bagged. A little to the north-west there is the outcrop of another lode, which can be traced for a considerable distance, showing lead carbonates of good quality.

Narra Tarra Lead Mine.—This consists of Freeholds 42, 336, 337, 830, and 833, and adjoins the last-mentioned to the

north-east. It was formerly worked by the Melbourne and Champion Bay Mining and Smelting Co., but now belongs to the Fremantle Smelting Co. All the lodes in the old mine run into it, whilst there is also a more western one, which is the main one, that has been worked. A vertical shaft, timbered and divided into three compartments, was sunk to a depth of 180 feet, with levels at 60, 120, and 180 feet. Owing, however, to the fact that it was sunk upon the cap of the lode, which was dipping to the south-east, crosscuts had to be driven from the shaft to the lode, the bottom one being 90 feet in length; it was therefore proposed to sink another shaft farther to the dip, with the object of cutting it at a depth of 300 feet, but, when this had been sunk 140 feet, the mine was abandoned. The lode near the shaft is said to have been nearly pure galena, from four to six feet in width. It is evident that a considerable quantity of work was done here, and a large plant has been in use, as well as smelting furnaces. Farther to the north-east are some more workings, where one shaft is down to a depth of 115 feet, and two or three other shafts of uncertain depth. The original management of this mine evidently failed to recognise the value of carbonates of lead, which were, in consequence, either not raised or tipped upon the dump; these are now being worked upon tribute, and 28 tons have already been dressed. This mine was worked from 1870 to 1884, during which time the company sent away £60,000 worth of ore. In the vicinity of these mines there are several other lodes which outcrop in places, upon which a little work has been done, but which have now been abandoned for many years.

Norman's Well Lead Mine.—This abandoned mine is situated upon the Narra Tarra-Northampton road, about seven miles from the latter township. The lode is well defined, starting in a north-easterly and south-westerly direction, with an underlie to the north-west at an angle of 60°. There are several shafts, the deepest of which is 80 feet, and, to judge from appearance, a good deal of lead must have been raised. The old dumps have recently been dressed, and several tons of galena obtained from them.

Gwalla Copper Mine.—This mine is situated upon the boundary of the township of Northampton, and consists of Freehold Blocks Nos. 140, 141, 250, 315, 331, and 359—covering a total area of 362 acres. There are two parallel lodes, which strike north-east and south-west, and dip to south-east. A considerable amount of work has been done upon the property, and several shafts sunk, the deepest being 198 feet upon the underlay. A main vertical shaft was in progress when the mine closed down, in 1868. This mine was only worked for a period of about five years, during which time 902 tons of ore, valued at £16,573, were raised. There were extensive buildings and plant upon this mine, most of which was left when the mine closed down.

Wanerenooka Copper Mine is situated at the north-west corner of the township of Northampton, and was worked about 45 years ago, but it was recently re-opened by an English company,

who did a considerable quantity of prospecting, but not finding any ore, closed down. The main shaft is 240 feet deep, from which there are several levels and drives, in which the lode proved to be about 30 feet in width, but carried rich ore in large bunches, sometimes upon one wall and sometimes upon the other. A winze has been sunk from the bottom level, in which there is said to be good ore. This company also owns Blocks 313, 27, 324, and 325, upon all of which lodes have been opened up to moderate depths.

Wheal Fortune Copper Mine.—This freehold property, consisting of Blocks Nos. 360, 334, and 437, is situated about three miles due west of Northampton. The main shaft on this mine is 300 feet in depth, and is connected with another, just outside the boundary, by a level some 500 feet in length. The lode when first opened up was only copper, but in depth a crosscourse was cut which carried lead, which cut out the lode, and thus the latter ore was worked. This mine was worked from 1862 to 1868, and produced 2,475 tons of lead and 985 tons of copper.

Rhys Lead Mine.—This is on a freehold block, No. 436, which adjoins the Wheal Fortune upon the east, and into which the main lode worked upon that property runs; in fact, one shaft has been sunk in it. The workings upon this property are situated a little further eastward, upon a galena lode, which has been opened up to a depth of 50 feet. This mine has been worked recently, as there are several tons of ore, dressed and bagged, still on the dressing floor.

Martin's Spring Copper Mine.—This mine is about three miles north of the Wheal Fortune, and is on a freehold block (No. 312) owned by the Wanerenooka Company. There are two shafts, the deepest of which is 42 feet, from which the lode was crosscut for a distance of 30 feet. Some of the copper from this mine carried a large percentage of silver, said to be as much as 50 ounces per ton. About a quarter of a mile farther south a third shaft has been sunk upon a lead lode, but little work has been done.

Woomboaro Lead Mine.—This mine is on a small freehold block, about half a mile south of Martin's Spring, where a lead lode was opened upon many years ago, but is a series of shallow pits and trenches.

Yanganooka Copper Mine.—This mine is about three miles north of Northampton, upon the main road, the area being held as freehold blocks, No. 32 and No. 314. There are two parallel lodes upon this property, which strike north-east and south-west, and dip at an angle of 75° north-west. The main workings are situated upon the western lode, which has been opened up by several shafts and levels, the deepest shaft being 180 feet. This mine has not been worked for 35 years, and the only record seems to be that the dressed ore went from 17 to 34 per cent., and the 458 tons sent away realised £5,880.

Baddera Lead Mine is situated upon Freehold Block 1472, about one and a-half miles to the north-east of the last mentioned.

There are two lodes upon this property, which run parallel in a north-east and south-west direction, dipping at a high angle to the north-west. These lodes vary from six inches to eight feet in width, the larger portion often consisting of almost pure carbonate or sulphide ore, which was so readily dressed by hand that the 677 tons of which a record has been kept averaged 72 per cent. The greatest amount of work has been done at the southern end of the lease, where the lode has been worked to a depth of 100 feet and 220 feet of drives. The other workings are at the north-east corner, where the lode has been opened up to a depth of 72 feet. This property was discovered in 1873 and worked for about 10 years, since which time little has been done. It now belongs to the Fremantle Smelting Company, who sunk a shaft to a depth of 160 feet, but stopped work before the lode was cut.

Wheal Mary Lead Mine.—This mine is situated upon a small freehold property about one mile south of the Baddera, and upon it a considerable quantity of work has been done; 2,200 tons of ore are said to have been sent away, but no work has been done during the last 12 years.

Wheal Ellen Lead Mine.—This mine, No. 1146, is another freehold belonging to the Fremantle Smelting Works Company, being situated about a mile in a south-west direction from Northampton. This lode which strikes in a north-east and south-west direction and dips to the north-west, was first opened in 1872, and vigorously worked for about 10 years, during which time it is estimated that £16,000 worth of ore was raised. The lode has been worked to a depth of 158 feet and driven on 1,200 feet.

Uga Lead Mine.—This abandoned lead lease was first opened in 1873. To judge from the extent of the old workings, the lode must have been of considerable size; whilst the refuse that remains after the ore dressing, proves that a large quantity of lode matter was dressed.

Strickland's Block 326.—The southern continuation of the Uga lode extends into this property. It is very similar in character, being well defined and of considerable width and length of chute. These two mines are said to have contributed a considerable proportion of the ore exported between 1873 and 1884, when the price of lead dropped.

Nooka Lead Mine.—This abandoned lease is situated nearly one mile north of the last mentioned, which it greatly resembles in character. It was opened upon to a depth of 90 feet, but a large quantity of the work consisted of open trenches and underlay shafts. This mine was worked in the later seventies, and is said to have produced about 1,000 tons of ore.

Chiverton Lead Mine.—This is also an abandoned lease, which adjoins the Nooka to the south, and into which that lode runs. This, however, has not been opened upon, but a parallel lode upon the western side of the lease has been worked to a limited

extent. This lode dips towards the Nooka lode, which it will probably junction with at a depth.

Kirton's Lead Mine.—This group of three abandoned leases was formerly known as Kirton's and West Wheal Virgin, and upon them a line of lode was opened for a distance of half a mile, there being three large chutes in this district, which have been worked upon, the three leases at the southern part to a depth of 100 feet, and the northern to 160 feet. In the central lease, whilst the Fremantle Smelting Company were prospecting, a low grade lode was driven through for a distance of 30 feet without any walls being met with. This mine was worked from 1873 to 1884, and was extremely rich in parts, being said to have yielded from four to six tons of clean galena per fathom in sinking.

Yiapa Lead Mine.—This is a small lease about six miles north of Northampton, and it is the farthest north of the group around that township. It is now held by Mr. Reynolds, who has a shaft down 90 feet, which is worked by a horse whip; there is another shaft down about 40 feet. This mine seems to be situated at the intersection of a mineral vein with a dyke, the ore chute being short, but rich. The shafts are now full of water.

Alma Lead Mine.—This is a small lease situated a little nearer to Northampton than the last mentioned, upon the western side of the road, and is held by Mr. Harvey, who has sunk a shaft to a depth of 42 feet, from which a little stoping has been done. The cap of the lode has also been opened by a series of small shafts and trenches. Twenty-eight tons of ore have been shipped from this mine.

Wheal Margaret Copper Mine consists of a number of abandoned leases about one mile east of Northampton. The lode is from seven inches to two feet in width, but pretty rich ore, and was worked by five shafts, close together upon the central lease, to a depth of 180 feet upon the underlay, and the chute stoped for a length of 200 feet. Very little has been done upon the other leases, although the continuation of the lode can be traced.

Victoria Copper Mine. — There are also a series of abandoned leases about half a mile south of the last mentioned, but, as upon the Margaret, although the lode can be traced for a considerable distance, it has only been worked at one point by two shafts about 100 feet apart. The great difficulty here was the great influx of water, whilst the ore was mixed with a large proportion of mundic.

Wheal Alpha Copper Mine.—This is also an abandoned lease, upon which a considerable amount of work has been done to a depth of about 60 feet. An attempt was recently made to sink a new vertical shaft, but this was abandoned.

Yankee Crossing Copper Mine.—This is another small abandoned lease, adjoining the Gwalla, and in this property a small but rich chute was worked to a depth of about 40 feet.

Geraldine Lead Mine.—This mine is situated upon Freehold Block No. 1, 40 miles north of Northampton, upon the Murchison River. It was worked from 1857 to 1878, during which period a considerable quantity of lead was raised and dressed. In the very earliest days smelting was attempted, but this proved a failure, so the ore was shipped from Port Gregory; but since no record of the ore shipped from this port has been kept independently of the general shipment, the quantity raised from this district cannot be estimated. The deepest shaft is 320 feet on the incline, and from this and the others there are very extensive workings.

Lady Florence Lead Mine is about one mile lower down the river upon Location 2, which belonged to the same company as the preceding. It is apparently a large, well-defined lode, which was worked by a number of shafts to a depth of from 60 to 80 feet, the ore being dressed at the Geraldine.

North Geraldine Lead Mine.—This is situated about one and a-half miles east of the Geraldine, upon Location 4, which was owned by the same company. It has not been extensively worked, the deepest shaft being only about 50 feet.

South Geraldine Lead Mine is situated upon Location 9, about two miles south of the Geraldine. This mine has not been worked for at least 20 years, but prior to that about 500 tons of galena are said to have been raised. The only shaft is down about 66 feet, but in it the lode is said to have been very rich.

Location No. 7 Lead Mine.—This mine is owned by the Wanerenooka Company. It was worked from 1888 to 1890, and is said to have yielded about 700 tons of ore. The deepest shaft is 44 feet, from which the lode has been driven upon, which proved to be very rich and pure.

Geraldine Copper Mine.—This mine, which consists of a number of leases, is situated about four miles north-east of the Geraldine mine. It is not being worked at present, but is still held. A shaft has been sunk to a depth of 150 feet, from which the workings are of considerable extent, which proves the existence of a very large lode, which is rich in places; 130 tons of ore, assaying 28 per cent., has been sent away the last year.

Lady Maude Lead Mine is a lease a little to the eastward of the last mentioned. It has been opened up to a depth of 50 feet, and from it 60 tons of galena have been shipped.

Ouraka Copper Mine is a lease a little south of the last mentioned. It has merely been prospected to a depth of 80 feet.

Hennings Copper Mine.—This is merely a prospecting show, a few pits having been sunk, and about five tons of ore raised from a small but rich vein.

Tambarra Copper Mine is a little north of the last mentioned, to which it is similar, the deepest shaft being 15 feet.

Gibson's Copper Mine is one of the same group, just to the north of the last named. It has been opened to a depth of 40 feet

upon a low grade lode, in which there is a rich ore chute, which increases in width from two inches at the surface to 18 inches at the shaft bottom.

Two Sisters Lead Mine.—These were two old leases held and worked by the Geraldine Company, who opened up a lode at various points for a distance of half a mile. The deepest shafts are from 60 to 70 feet, but the whole of the lode has been taken out up to the surface, and appears to have been from 10 to 15 feet wide at the chutes.

Four Mile Pool Lead Mine.—This lode is situated south-west of the last, and is probably only the same vein ; only a little work has been done on it of a purely prospecting nature.

Mary Spring Lead Mine.—This old mine, that was worked by the Geraldine Company, is about four miles north of the Geraldine Copper Mine, and on it two parallel lodes have been worked to a depth of 75 feet, from which, apparently, a large quantity of ore was taken and dressed at the Geraldine.

Lady Tilly Lead Mine is about one and a-half miles north-west of the Geraldine Copper Mine. Very little work has been done upon it, but 120 tons of ore is said to have been shipped.

Wheal Lily Lead Mines is situated upon the south side of the river, about three miles east of the Geraldine mine. There are several old shafts, but as the ore has been stoped to the surface, these have mostly fallen in. The lode was apparently of good size, and a good deal of ore is said to have been sent away.

General.—It will be seen from the above that in all 45 properties are included, out of which 16 are copper and 29 lead, whilst 22 are situated upon freehold property, and 23 upon Crown lands. With the exception of one or two, the freehold properties are by far the most valuable, but since no regulations apply to them, there is no prospect of their being worked. The four most important lead mines were the Geraldine, the Narra Tarra, the Wheal Ellen, and the Baddera; and they are all freehold. With regard to the copper mines, the same remarks may apply, since there is no single leasehold copper mine that has acquired any prominence as an ore producer. If, however, an average is struck, we find that in the last 50 years the 16 copper mines have produced about 8,000 tons of ore, and the 29 lead mines 33,500 ; or 500 tons of copper and 1,155 tons of lead to each mine.

At the present time there are only a few small lodes that could be made productive without the expenditure of considerable capital. This condition of things is really the fault of the local miners, who, in their desire to obtain every scrap of ore, have rendered the workings not only unsafe, but have precluded their use for further development or prospecting, thus entailing the necessity of shaft sinking to a depth of 100 feet and more, in order to prove whether a payable lode does exist or not.

30th May, 1901. H. P. WOODWARD.

APPENDIX B.

RESULTS OF BORING.

In the year 1901, Messrs. Woodward and Lightly were commissioned to visit the Murchison district in connection with a proposal to erect State smelting works at Geraldton. As a result of their investigations it was recommended, *inter alia,* that a diamond drill be sent up to the district with a view of testing some of the lodes at a depth. Instructions were ultimately issued for the selection of sites for experimental boring to be carried out on Crown Lands.

A site was eventually selected at the Wheal Margaret Copper Mine. The lode is embraced within the limits of a number of abandoned leases, lying about one mile to the East of Northampton. The "Wheal Margaret" lode is said to have varied from seven inches to two feet in width of pretty rich ore. The lode was originally worked by five shafts, which were put down in close proximity in the central lease to a depth of 180 feet in the underlay, and the chute stoped out for a length of 200 feet. Boring operations commenced on the 12th of July, and were suspended on the 8th of October, after the drill had penetrated to a depth of 651 feet. Operations commenced at a point about 257 feet from the outcrop, and boring was carried out at an inclination of about 59 degrees from the horizontal. The bore proved unsuccessful; full details of the strata pierced are found in the Plate herewith. It is conceivable that what is shown in the bore record as fault rock (lode stuff ?) occurring between 387 and 408 feet, may represent the Wheal Margaret lode, occurring along a line of fault; if so, the drill pierced the deposit at a point where it happened to be poor. The total cost of the bore, including incidentals, etc., amounted to £807 16s. 5d.

The second bore was put down at the Old Cow Rock, at Narra Tarra, at an angle of 45 degrees. Operations were commenced on the 1st of November, 1902, and ceased on the 3rd February, 1903, having penetrated to a depth of 600 feet. The drill passed through more or less decomposed granite. At 83 and 90 feet, bands of decomposed rock, with a little copper sulphide, were passed through, and at 239 feet a small quartz leader, carrying a little galena and zincblende, was met with. The bore-hole intersected no lode of any importance. Particulars of the strata pierced will be found on the accompanying Plate.

The total cost of this hole amounted to £635 18s. 11d

A. GIBB MAITLAND,

24th April, 1903. Government Geologist.

APPENDIX C.

THE NORTHAMPTON MINING DISTRICT.

According to instructions received from the Honourable the Minister for Mines, I paid a visit to Northampton, leaving Perth on the 17th May, and returning on 2nd June.

As far as I can gather, the first discovery of copper ore was made in this district in 1842, when the Wanerenooka mine was discovered, and operations were commenced and continued actively for some 10 or 12 years after. Several other copper mines were subsequently opened, then lead mines; the lead mines ultimately predominating over the copper mines in the larger output.

The value of lead ore raised in this district up to 31st October, 1899, is given me as £364,514, being the value of 33,617 tons of ore shipped. The value of copper ore raised up to 31st October, 1899, is given as £457,944 from 9,349 tons of ore. For the last 30 years the district has been practically idle. No mines are now being worked, and the miners seem either to have left the district or settled down to farming in the immediate vicinity of the mines.

The district is about 110 miles in length, and extends from the Geraldine mine on the Murchison River in the north, to the Irwin River in the south, and is about 30 miles wide.* Throughout the whole district, mining has now entirely ceased, and it is pitiable to see so much utter desolation and abandonment as the shafts present with their surface timbers and collars all removed, and the sides caved in. The refuse heaps have been picked over and over again, so that they are now as clean and free from payable ore as they can well be.

The mines I visited were as follow :—

WANERENOOKA MINE.—It is situated on the northern boundary of the township of Northampton, on Block 27. Its area is 60 acres. A considerable amount of work has been done here. There is a good three-compartment shaft sunk to a depth of 240 feet vertical. The lode is reported to have passed through the shaft at the 180 feet level, and since then has not been seen. There is an open cut for about 250 feet north of the main shaft, which has been filled in with waste rock. Ore is reported to be standing at the 138 feet level and at the 180 feet level. Galena occurs occasionally with the copper ore, but I was unable to ascertain if any had been sold. About 120 feet north-east from the shaft a winze has been sunk 60 feet below the 180 feet level which carries a bunch of black ore, said to be rich enough to pay working expenses. The walls of the lode are stated to be 30 feet apart, smooth, and well defined, with a payable streak on the hanging wall and another on the footwall, averaging one foot in width. It is reported

* The proclaimed Mining District extends only as far south as the Chapman River, and is 67 miles in length and 24 miles in width in its widest part, from which it will be seen that the legal boundaries do not coincide with the geological boundaries.—A.G.M.

that it took two and a-half years to sink this shaft this last 60 feet, a work which could easily have been done in six weeks.

Victoria Copper Mine.—There are two shafts here, situated on the crest of a hill and about 200 feet apart, from which a considerable amount of ore is said to have been raised. The ores are apparently yellow sulphides, although it is reported that a good body of black sulphides existed between the shafts, which, when extracted, realised sufficient to pay the entire costs of the eight men who were steadily working here. The ore-body is stated to have been two feet six inches wide, and the lode seven feet wide. There is a drive at 36 feet, connecting these two shafts. One of these is 60 feet deep and the other 50 feet deep. The lode may be traced on surface for a distance of two miles from these shafts. North-east from these shafts is another small shaft at about 60 feet distant, which is 25 feet deep. This mine is situated one mile and a quarter east from the railway station.

Wheal Margaret.—Several shafts have been sunk on this block. One, a two-compartment shaft, is said to be 30 fathoms deep, and a fair quantity of ore has been raised. Travelling north from this shaft are several shallow workings, from all of which ore has been raised. These workings have since caved in and are full of water. The ores found were principally green and blue carbonates. Sulphides are just coming in, in the bottom of the shaft. The property is situated one mile north-east from the railway station.

Wheal Fortune.—There is a shaft here said to be 300 feet deep, which has an 8-inch cast iron water-pipe column standing in it. The mouth of the shaft is badly caved in, and I doubt if it would be economical to repair and clear it for further work. The refuse heaps seem to be soft clayey decomposed rock, and to have carried carbonate ores of good quality for copper. Working ceased here 35 years ago, and since then nothing has been done. Another shaft, known as the "Old Wheal Fortune," is situated in a hollow close by, where water would be expected to be plentiful. This is about four miles west from the railway station.

Wheal Fortune Extended or Rhy's Mine.—Two small shafts have been sunk about eight fathoms deep, and there are some 60 bags clean galena ore lying at the surface. There are numerous shallow holes near the shafts from which ore has been taken out. A horse whim seemed to be the only machine used here. Everything seemed cleaned right up. The mine is situated three miles north-west from the railway station.

South Kirton's and North Kirton's.—These are a group of mines about four miles from Northampton. In South Kirton's there are two or three shallow workings near the bottom of a depression, but no ore is visible in any of them. The lode is traceable for a considerable distance along the depression. To the north of these workings is another shaft, near which is a pile of some 20 tons of lode matter which carries galena. This would require dressing before being fit for the market.

In the North Kirton's is a shaft on which an engine had been used, and a small heap of lode matter, said to have come from the bottom of the shaft, shows a little lead, say, from 5 per cent. to 10 per cent., in a quartz matrix. The lode has been traced on the surface for about 150 feet north from the shaft.

Wheal Beta.—This mine was worked by T. Scott. Two shafts have been sunk, 120 feet apart, on the crest of a hill; one is 54 feet deep, and the other 48 feet deep. Everything in the shape of ore has been cleaned up, and the mouth of the shaft caved in. It is two miles from the railway station.

Wheal May.—Three shafts have been sunk here, the deepest being 90 feet. About 250 feet of driving on the lode has been done. The lode averages 18 inches in width. There is a six-inch Cornish lift in one of the shafts and an engine to drive it.

Mr. Chism, a former manager here, tells me he took out 2,200 tons of lead ore, which realised £14 per ton. Work was suspended entirely, owing to a depressed lead market, and not from any want of lead ore or pinching of the lode.

Baddera Mines.—These mines are situated about six miles from Northampton railway station, and, judging from the large heaps of lodestuff lying about, I should say that a considerable amount of work has been done. The mine was discovered in 1873, and afterwards fell into the hands of Messrs. Crowther and Mitchell. The old shaft is about 15 fathoms deep, and about 130 feet has been driven on the lode, which has been stoped away right to the surface from the level, said to be 25 feet deep. A vertical shaft has been sunk more recently. This is said to be 80 feet deep, and at the bottom a crosscut has been driven 36 feet to intersect the lode. Another shaft is said to be 14 feet deep. The lode is said to be in good ore under foot in the level, and, as far as I could see, this property would be very productive of lead ore if again worked.

Ukkerheri Mine.—This mine is about two miles north from the Baddera mine. There is one shaft about five fathoms deep, from which a little lead ore has been sold, but very little work has been done. It was worked in the early days by one John Hosking, and subsequently by James Mitchell.

Yiapa Mine.—A little work has been done on a lode 3 feet wide. A shaft has been sunk 90ft. in soft, easy ground. There is about 10cwt. galena on the floors and a small pile of two tons seconds. This mine has produced 500 tons to 600 tons of galena.

Alma Mine.—A shaft has been sunk in soft, decomposed country 48 feet deep. A little galena is showing in the lode near the surface, which is about three feet wide. No walls are showing. The lode has been traced on the surface for a distance of 1,500 feet.

Yanganooka Mine.—An old working stopped many years ago. The shaft has fallen in and there is a general wreck. I saw some good stones of copper ore said to have come from the bottom of the mine. The mine is on private property, and I could get no information as to the size and productiveness of the lode.

Iga Mine is about quarter of a mile south of Yanganooka mine. Not much work has been done, but it is reported that some 400 tons of ore were shipped from here.

Gwalla Mines are located on the south side of the township of Northampton. The railway terminus is situated within the boundaries of the property. There are two parallel lodes, a shaft has been sunk to about 200 feet, and seems to have been well equipped with pumping and winding gear, and there has also been some attempts at ore dressing. It was discovered in 1863, and was very successfully worked for some time.

Camp Hill Mine adjoins the Gwalla mines on the west. Two shafts have been sunk about 50 feet each. No information was available as to quantity and quality of ore yielded.

Wheal Ellen.—This has been one of the best lead mines in the district, and a large amount of work has been done, and there seems to have been a continuous chute of ore for about 300 feet in length on the surface. There was a pumping engine and dressing plant here in operation, and ores used to be dressed from the Baddera mines as well as the Wheal Ellen mines. This mine was first opened in 1872, and returned about 1,000 tons of lead ore per annum whilst being worked. This mine is said to be only 26 fathoms deep, and the length of the workings 200 fathoms.

Strickland's Block, or South Uga, is about west of north from Wheal Ellen three-quarters of a mile. This shaft is 12 fathoms deep, and I am told there is two feet of clean galena in the bottom of the shaft.

Uga Mine.—The shaft is 75 feet deep. This mine is said to have produced a large quantity of lead ore. The ore has been stoped up to the surface. The appliances for hoisting were too crude to enable them to go deeper.

Chiverton Mine.—This shaft is said to be seven fathoms deep. There is a little blende to be picked up on the surface, but not enough to be payable.

Nooka Mines.—These have been fair producers. There is a quantity of blende associated with the lead ores. It is stated that there is a good body of blende opened up in the mine, which is 14 fathoms deep.

Wheal Alpha Mine.—This is about one mile and a quarter east from Northampton, and is a copper show. Three shafts have been sunk, the deepest being about 60 feet. The lode at the surface is one foot six inches wide. Water is stated to be plentiful here, and the ground seems favourable for the production of mineral. A vertical shaft sunk by Mr. S. Mitchell, 25 feet deep, did not reach the lode.

Martin's Spring Mine.—Two shafts have been sunk here, one 42 feet, the other 50 feet, and a level connects them. There are other smaller workings to the south on the same block. Lead and copper ores occur in the lode, and are said to contain an appreciable quantity of silver. A parcel of copper ore was sold at a very

satisfactory return, and was said to contain 55 per cent. copper. The lode is 25 feet wide, and the ore makes in bunches throughout the whole width of the lode. No walls have been reached in the last working. There has been about 20 tons of ore sold from here. No work has been done along the course of the lode.

SCOTT AND GALE'S MINE.—South of Martin's spring, on block 312, a shaft was sunk 54 feet, and a fair parcel of galena was sent away. The lode has been traced north from the shaft for a considerable distance.

Wanerenooka Estate have a block north of this, about a quarter of a mile distant, and a small working which is said to be on the same lode.

NORMAN'S WELL OR NORMANTINE MINE.—Several shafts have been sunk on the top of a hill, the lode showing clearly at surface for a long distance. One of the shafts has an abundant supply of good water, which is now being used to irrigate an orchard close by. The lode seems much mixed up with quartz and garnets where I saw it.

NARRA TARRA LEAD MINES.—These are situated some 13 miles south-east from Northampton. A considerable amount of work has been done here, and the lode, which is reported to have consisted of pure galena in places, is from four feet to six feet in width. The output from the mine is valued at £60,000, and the depth of the shaft at 30 fathoms. The mines seem to have been well equipped with machinery.

GENERAL.—There are also some mines at McGuire's, Oakajee, and White Peak. At White Peak but little work has been done. I saw some copper stains near one of the workings, but the ores were evidently poor in quality. At Gelirah, two lodes have been worked and a considerable quantity of copper raised. Time did not allow me to visit this mine.

ZINC BLENDE.—A careful search over the refuse heaps at the various mines visited leads me to the conclusion that blende was not so plentifully found as was generally reported. It certainly does occur in several of the mines, notably, Wheal Ellen, Nooka, and Uga mines, and at Nooka and Uga mines might pay to work in conjunction with the lead ores.

While I am satisfied that there are abundant supplies of lead and copper ores in the Northampton district, I am not so sanguine of their being worked at a profit owing to the present low price of lead and comparatively low price for copper. With galena and blende marketable something might be done, provided sufficient capital was available to give any one of the mines a thorough test. A pumping plant and small winding engine would be indispensable. With these provided, £5,000 should be able to thoroughly test a property, as the ground is not hard, nor are wages exorbitantly high.

JOHN PROVIS, F.C.S.,
Ass. Mem. Inst. C.E.

17th June, 1903.

Appendix D.

Table of Assays of Copper and Lead Ores *from the Northampton Mining District made in the Geological Survey Laboratory.*

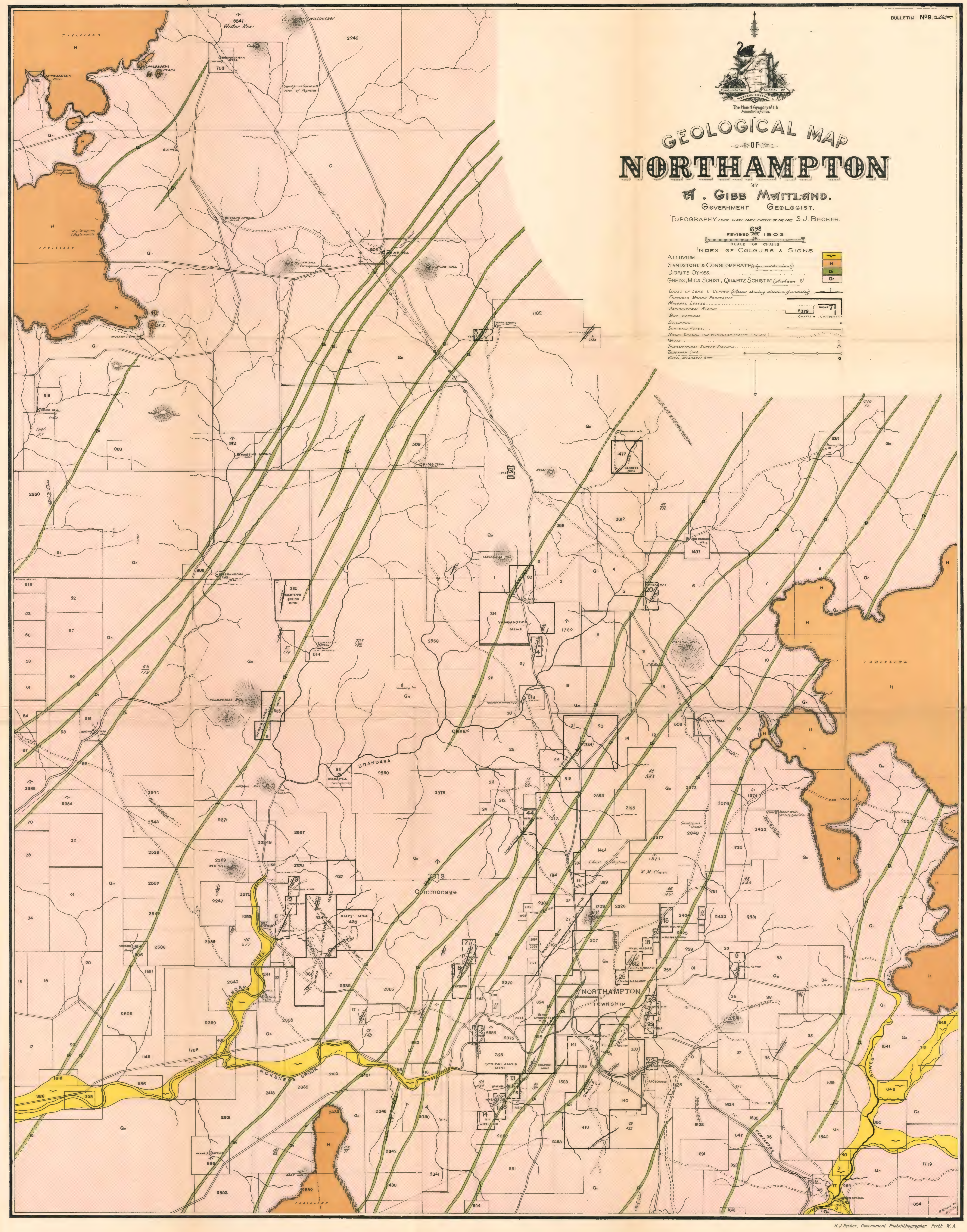
Lab. No.	Mine.	Locality.	Nature of Ore.	Copper.	Lead.	Silver.	Gold.
				parts per 100.		oz. per ton.	
3105	Wanerenooka	Northampton	Chalcopyrite and quartz ...	6·54	*Nil*	...	...
M183	Nooka ...	do. ...	Chalcopyrite, galena, and quartz	5·34	8·6	*Nil*	*Nil*
...	Racecourse	do. ...	Cupriferous gossan ...	8·08	...	0·87	*Nil*
3905	Derby Syndt.	do. ...	Chalcopyrite and quartz ...	24·01	*Nil*	1·76	0·05
3906	Do.	do. ...	do.	13·52	*Nil*	0·44	*Nil*
673	?	do. ...	Malachite, iron oxides, etc.	18·63	...	2·29	trace
674	?	do. ...	do.	15·08	8·8	*Nil*	*Nil*
675	?	do. ...	do.	14·48	...	*Nil*	*Nil*
676	?	do. ...	do.	31·94	...	2·45	trace
677	?	do. ...	do.	37·85	...	...	...
672	?	do. ...	Galena and quartz	...	70·3	0·26	*Nil*
1559	Geraldine ...	Geraldine ...	Pyromorphite	*Nil*	62·5	*Nil*	*Nil*
4134	McGuires ...	Oakabella ...	Galena, chalcopyrite, and quartz	1·75	39·5	*Nil*	*Nil*
3281	Lauder's ...	Narra Tarra	Cerussite	*Nil*	66·9	0·25	trace
3943	Mendip ...	do. ...	Cerussite and quartz ...	...	50·7	0·45	trace
3944	Do. ...	do. ...	do.	...	54·0	0·72	*Nil*
3945	Do. ...	do. ...	Galena, cerussite, and quartz	...	64·1	2·41	trace
3930	Narra Tarra Lead	do. ...	Galena, blende, quartz, and granite	...	59·3	0·16	*Nil*
3931	Do. ...	do. ...	Cerussite, galena, and quartz	...	39·6	1·38	*Nil*
3941	Do. ...	do. ...	do.	...	52·4	3·76	trace
3942	Do. ...	do. ...	Cerussite and quartz ...	...	44·3	0·98	trace
4135	Do. ...	do. ...	Galena and quartz	...	59·5	*Nil*	*Nil*
3925	Narra Tarra Copper	do. ...	Azurite and quartz ...	14·61	*Nil*	2·33	0·11
3926	Do. ...	do. ...	Azurite, malachite, and quartz	8·98	*Nil*	1·07	trace
3927	Do. ...	do. ...	Galena, cerussite, and quartz	...	46·7	0·57	*Nil*
3928	Do. ...	do. ...	do.	...	51·0	0·73	*Nil*
3929	Do. ...	do. ...	do.	...	63·2	2·94	*Nil*
4281	Gelirah ...	White Peak	Chalcocite, quartz and iron oxide	21·99	...	...	...

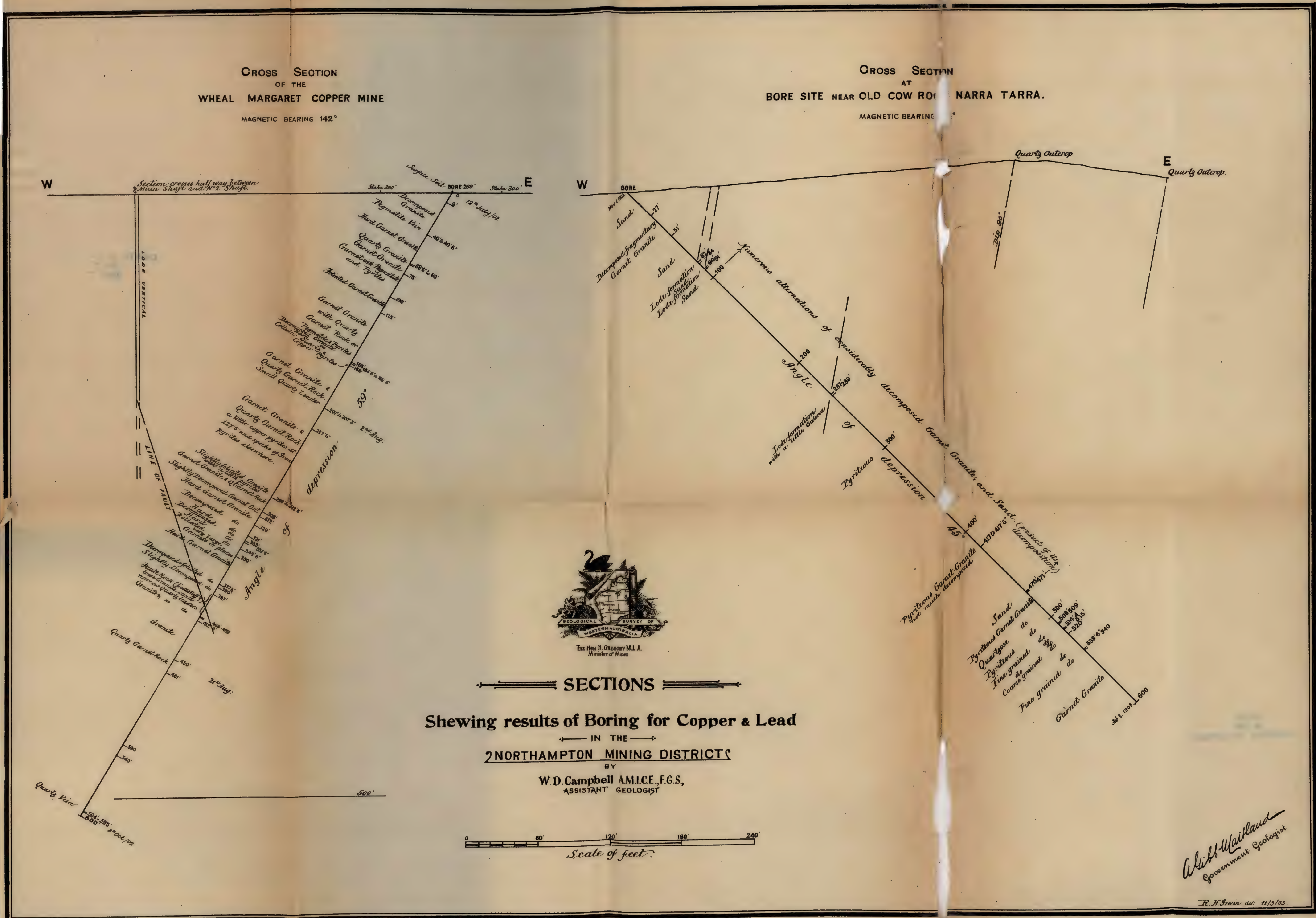
Analysis of a Sample of dark brown Zinc Blende *from the Nooka Mine, Northampton.*

Zinc, Zn	59·04
Cadmium, Cd	5·78
Iron, Fe	2·08
Lead, Pb	·37
Sulphur, S	32·66
	99·93
Specific gravity ...	4·07

EDWARD S. SIMPSON, B.E., F.C.S.,
Mineralogist and Assayer.

By Authority: Wm. Alfred Watson, Government Printer, Perth.


BULLETIN No 9.
GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
The Hon: H. Gregory M.L.A. Minister for Mines.
GEOLOGICAL MAP OF NORTHAMPTON
BY
A. GIBB MAITLAND.
GOVERNMENT GEOLOGIST.
TOPOGRAPHY FROM PLANE TABLE SURVEY BY THE LATE S.J. BECHER.
1898 REVISED 1903
SCALE OF CHAINS
INDEX OF COLOURS & SIGNS
ALLUVIUM
SANDSTONE & CONGLOMERATE (Age undetermined)
DIORITE DYKES
GNEISS, MICA SCHIST, QUARTZ SCHIST &c (Archaean ?)
H
Di
Gn
LODES OF LEAD & COPPER (Arrow shewing direction of underlay)
FREEHOLD MINING PROPERTIES
MINERAL LEASES
AGRICULTURAL BLOCKS
MINE WORKINGS
SHAFTS
COSTEENS
BUILDINGS
SURVEYED ROADS
ROADS SUITABLE FOR VEHICULAR TRAFFIC (IN USE)
WELLS
TRIGOMETRICAL SURVEY STATIONS
TELEGRAPH LINE
WHEAL MARGARET BORE
TABLELAND
NORTHAMPTON
TOWNSHIP
Commonage
UDANDARA
CREEK
NOKENENA BROOK
BOWES RIVER
STRICKLAND'S MINE
RHYS' MINE
YANGANOOKA MINE
MARTIN'S SPRING MINE
BADGERA MINE
Church of England
W. M. Church
6547 Water Res.
H. J. Pether, Government Photolithographer, Perth, W. A.



H. J. Pether, Government Photolithographer, Perth, W.A.